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SPECTACLE AND CONTACT LENS SELECTING SYSTEM AND METHOD THEREOF

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a spectacle and contact lens selecting system and a method thereof, and in particular, to a spectacle and contact lens selecting system and a method thereof, which enable the selection of spectacles and contact lenses fitted to each person on a computer network.

2. Description of the Related Art

Conventionally known as means for selecting spectacles lenses are methods which utilize eyeball models. As the eyeball models, well known are the Gullstrand eyeball model and the Le-Grand eyeball model.

These eyeball models have been used entirely for the design and evaluation of spectacles lenses. For the design of spectacles lenses, one standard model prepared as an optical eye model would make it possible to design lenses having various powers for standard eyes. This is sufficiently enough for the design irrespective of the eye structure of a person because he/she can select among spectacles lenses prepared every power of 0.25D by actually wearing them, thereby ensuring that he/she finds spectacles lenses suitable for

correction. That is, there is a flexibility of selection.

These days, on the other hand, to measure uncorrected or corrected vision, one goes to see an ophthalmologist or has his/her vision measured at spectacles shops using their optometers.

Recently, for example, virtual malls are available over networks such as the Internet; however, any of the spectacles shops available in these virtual malls provides no system for measuring the uncorrected and corrected vision on an on-line basis.

However, to solely determine the power of spectacles lenses suitable for the eyes of an individual, an optical model such as the eyeball model assumed to be commonly applicable to everyone would cause significant error in optical calculation thereby making the determination impossible. The determination can be made only by constructing an eyeball model for each person.

Using the conventional eyeball models, as they are, will raise the following problems. That is,

· Since the conventional eyeball model is based on measurements made on eyes of people from Europe and the United States, they cannot be used for constructing a model having values close to those obtained by measuring living eyes of other races, e.g., Japanese people. For example, Japanese have a smaller radius of curvature of the cornea than do people from Europe and the

United States.

· A model is prepared based on an average of measurements.

Literatures show such data that the depth of the anterior chamber of the eye varies with age or the length of the eye axis is correlated with the degree of myopia for low degrees of shortsightedness. Thus, it is apparently necessary to construct an eyeball model according to the age and the degree of myopia of each individual.

· Although the lens of the eye has a refractive index unevenly distributed, the average refractive index is used. The simplified double structure provided to the lens of the eye causes a significant error in tracking rays of light.

On the other hand, where difficulty is found in visiting medical care providers or spectacles shops such as due to the time required and the distance traveled for the visit, there has been a need for implementing a system which enables one to remotely measure his/her vision over the Internet.

In particular, one's currently wearing spectacles or contact lenses may provide more blurred viewing than before. In this case, it would be very convenient if one can remotely measure his/her uncorrected and corrected vision in order to determine whether he/she needs to buy new spectacles or contact lenses.

Moreover, if a user can see himself/herself wearing spectacles or contact lenses at the selection of spectacles or

contact lenses, the selection of spectacles or contact lenses can be further ensured with increased facilitation.

It is therefore a principal object of the present invention to provide a system and method for determining an spectacles/contact lens power suitable for an individual, and for confirming wearing condition.

SUMMARY OF THE INVENTION

A spectacle and contact lens selecting system set forth in claim 1 of the present invention, comprises: input means for inputting information related to a state of eyes of a user; eyeball optical model deciding means for deciding an eyeball optical model corresponding to the information related to the state of the eyes input by the input means; eyeball accommodation range determination means for examining optical performance of an eyeball within a range of accommodation of the user in the eyeball optical model decided by the eyeball optical model deciding means to determine the range of accommodation of the eyeball; lens power selecting means for examining optical performance when the user wears spectacles or contact lenses to select a lens power; and wearing state display means for generating and displaying a wearing state of the spectacles or the contact lenses to be selected.

The spectacle and contact lens selecting system set forth in claim 2 of the present invention is recited in claim 1,

wherein the input means is configured so as to allow the user to input information of the eyes of the user such as a wearing condition of the user, an age, a near point distance, a far point distance, or a vision at a constant distance.

The spectacle and contact lens selecting system set forth in claim 3 of the present invention is recited in claim 1 or 2, wherein the eyeball optical model deciding means comprises start eyeball optical model deciding means for deciding a start eyeball optical model based on the information of the eyes of the user such as an age and an approximated lens power.

The spectacle and contact lens selecting system set forth in claim 4 of the present invention is recited in any one of claims 1 to 3, wherein the eyeball optical model deciding means is configured so that a focal state in the eyeball of the user at an accommodation midpoint calculated from a near point distance and a far point distance of the user becomes optimal and/or a focal state in the eyeball of the user in a non-accommodative state calculated from the far point distance of the user becomes optimal.

The spectacle and contact lens selecting system set forth in claim 5 of the present invention is recited in any one of claims 1 to 4, further comprising eyeball optical model validity examination means for examining validity of the eyeball optical model at a limit of accommodation on a near point side and/or on a far point side.

The spectacle and contact lens selecting system set forth in claim 6 of the present invention is recited in any one of claims 1 to 5, wherein the eyeball accommodation range determination means is configured to be able to determine a range of accommodation of optical dimensions of the eyeball at an accommodation midpoint.

The spectacle and contact lens selecting system set forth in claim 7 of the present invention is recited in any one of claims 1 to 6, further comprising eyeball optical model image generating means for generating and displaying an image of an eyeball optical model in which the range of accommodation of the eyeball is determined.

The spectacle and contact lens selecting system set forth in claim 8 of the present invention is recited in any one of claims 1 to 7, further comprising eyeball optical model focal performance examination means for examining focal performance of the eyeball optical model at a near point or a position within a range of accommodation ability in the vicinity of the near point, at a far point or a position within the range of accommodation ability in the vicinity of the far point, or at a position away from the near point and the far point in a naked eye state of the user.

The spectacle and contact lens selecting system set forth in claim 9 of the present invention is recited in claim 8, wherein the eyeball optical model focal performance

examination means comprises means for examining a focal state of the eyeball optical model of the user at the near point or the position within the range of accommodation ability in the vicinity of the near point, at the far point or the position within the range of accommodation ability in the vicinity of the far point, or the position away from the near point and the far point after vision correction with the spectacles or the contact lenses.

The spectacle and contact lens selecting system set forth in claim 10 of the present invention is recited in any one of claims 1 to 9, further comprising sharpness score generating means for generating a sharpness score of visibility of the user before and/or after vision correction with the spectacles or the contact lenses.

The spectacle and contact lens selecting system set forth in claim 11 of the present invention is recited in any one of claims 1 to 10, further comprising viewed image generating means for generating an image to be viewed by the user before and/or after vision correction with the spectacles or the contact lenses.

The spectacle and contact lens selecting system set forth in claim 12 of the present invention is recited in any one of claims 1 to 11, wherein the wearing state display means comprises: image acquisition means for acquiring an image of the user; and image synthesizing means for synthesizing an

image of spectacles or contact lenses to be selected and the acquired image of the user.

A spectacle and contact lens selecting method set forth in claim 13 of the present invention, comprises the steps of: inputting information related to a state of eyes of a user; deciding an eyeball optical model corresponding to the information related to the state of the eyes input by the input step; examining optical performance of an eyeball within a range of accommodation of the user in the eyeball optical model decided by the step of deciding the eyeball optical model, to determine the range of accommodation of the eyeball; examining optical performance when the user wears spectacles or contact lenses to select a lens power; and generating and displaying a wearing state of the spectacles or the contact lenses to be selected.

The spectacle and contact lens selecting method set forth in claim 14 of the present invention is recited in claim 13, wherein the input step comprises the step of inputting information of the eyes of the user such as a wearing condition of the user, an age, a near point distance, a far point distance, or a vision at a constant distance.

The spectacle and contact lens selecting method set forth in claim 15 of the present invention is recited in claim 13 or 14, wherein the step of deciding the eyeball optical model comprises the step of deciding a start eyeball optical model

based on the information of the eyes of the user such as an age and an approximated lens power.

The spectacle and contact lens selecting method set forth in claim 16 of the present invention is recited in any one of claims 13 to 15, wherein the step of deciding the eyeball optical model comprises the step of deciding the eyeball optical model so that a focal state in the eyeball of the user at an accommodation midpoint calculated from a near point distance and a far point distance of the user becomes optimal and/or a focal state in the eyeball of the user in a non-accommodative state calculated from the far point distance of the user becomes optimal.

The spectacle and contact lens selecting method set forth in claim 17 of the present invention is recited in any one of claims 13 to 16, further comprising the step of examining validity of the eyeball optical model at a limit of accommodation on a near point side and/or on a far point side.

The spectacle and contact lens selecting method set forth in claim 18 of the present invention is recited in any one of claims 13 to 17, wherein the step of determining the range of accommodation of the eyeball comprises the step of determining a range of accommodation of optical dimensions of the eyeball at an accommodation midpoint.

The spectacle and contact lens selecting method set forth in claim 19 of the present invention is recited in any one of

claims 13 to 18, further comprising the step of generating and displaying an image of an eyeball optical model in which the range of accommodation of the eyeball is determined.

The spectacle and contact lens selecting method set forth in claim 20 of the present invention is recited in any one of claims 13 to 19, further comprising the step of examining focal performance of the eyeball optical model at a near point or a position within a range of accommodation ability in the vicinity of the near point, at a far point or a position within the range of accommodation ability in the vicinity the far point, or at a position away from the near point and the far point in a naked eye state of the user.

The spectacle and contact lens selecting method set forth in claim 21 of the present invention is recited in claim 20, wherein the step of examining the focal performance of the eyeball optical model comprises the step of examining a focal state of the eyeball optical model of the user at the near point or the position within the range of accommodation ability in the vicinity of the near point, at the far point or the position within the range of accommodation ability in the vicinity of the far point, or at the position away from the near point and the far point after vision correction with the spectacles or the contact lenses.

The spectacle and contact lens selecting method set forth in claim 22 of the present invention is recited in any one of

claims 13 to 21, further comprising the step of generating a sharpness score of visibility of the user before and/or after vision correction with the spectacles or the contact lenses.

The spectacle and contact lens selecting method set forth in claim 23 of the present invention is recited in any one of claims 13 to 22, further comprising the step of generating an image to be viewed by the user before and/or after vision correction with the spectacles or the contact lenses.

The spectacle and contact lens selecting method set forth in claim 24 of the present invention is recited in any one of claims 13 to 23, wherein the step of generating and displaying the wearing state comprises: the step of acquiring an image of the user; and the step of synthesizing an image of spectacles or contact lenses to be selected and the acquired image of the user.

The above and other elements, characteristics, features and advantages of the present invention will be apparent from the following detailed description of preferred embodiments of the present invention with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a diagram showing an example of a system configuration of a spectacle and contact lens selecting system in an embodiment of the present invention;

Fig. 2 is a diagram showing the schema of a process when a user purchases spectacles or contact lenses;

Fig. 3 is a diagram showing the schema of a process of categorizing the user in the process of the spectacle and contact lens selecting system;

Fig. 4 is a diagram showing the schema in the case where the user is a returning customer;

Fig. 5 is a diagram showing the schema of a process in the case where the user is not a customer but has a prescription;

Fig. 6 is a diagram showing the schema of a process in the case where the user is not a customer, does not have a prescription, and is not destined to wear a pair of spectacles for presbyopia;

Fig. 7 is a diagram showing the schema of a process in the case where the user is not a customer and does not have a prescription with no subjective symptom of presbyopia;

Fig. 8 is a diagram showing the schema of a process in the case where the user prefers a pair of ready-made spectacles for presbyopia;

Fig. 9 is a view showing a lens selection criterion database;

Fig. 10 is a view showing a lens database;

Fig. 11 is a schematic view of a screen at the top of a site;

Fig. 12 is a schematic view of a collecting screen of personal computer screen information;

Fig. 13 is a schematic view of a service selection screen;

Fig. 14 is a schematic view of a screen at the top of frame selection;

Fig. 15 is a schematic view of a PD measurement screen;

Fig. 16 is a schematic view of a facial image selection screen;

Fig. 17 is a schematic view of a self-portrait upload screen;

Fig. 18 is a schematic view of a virtual frame selection screen;

Fig. 19 is a schematic view of a different color display screen;

Fig. 20 is a schematic view of a saved-item confirmation screen;

Fig. 21 is a schematic view of a purchased frame confirmation screen;

Fig. 22 is a schematic view of a lens power selection screen for having spectacles made;

Fig. 23 is a schematic view of a prescription data entry screen;

Fig. 24 is a schematic view of a lens thickness comparison screen;

Fig. 25 is a diagram showing an example of a configuration of a lens virtual try-on system equipped for the spectacle and contact lens selecting system in an embodiment of the present invention;

Fig. 26 is a view showing an example of a database related to user information;

Fig. 27 is a view showing an example of data input by frame selection information input means;

Fig. 28 is a view showing an example of a database structure related to a functional structure of a frame;

Fig. 29 is a view showing an example of a database structure related to a decorative structure of a frame;

Fig. 30 is a schematic view showing a measurement method on the lateral side of a facial image;

Fig. 31 is a schematic view showing a measurement method on the front side of the facial image;

Fig. 32 is a schematic view showing a frame adjusting method;

Fig. 33 is a view showing an example of a configuration of a remote subjective vision test system equipped for the spectacle and contact lens selecting system in the embodiment of the present invention;

Fig. 34 is a flowchart of screens for lens power decision (No. 1);

Fig. 35 is a flowchart of screens for lens power decision

(No. 2);

Fig. 36 is a schematic view of a personal computer screen information collecting screen;

Fig. 37 is a schematic view of a user information entry screen;

Fig. 38 is a schematic view of a wearing condition entry screen;

Fig. 39 is a schematic view of a guidance screen displayed at an astigmatism axis measurement step 1;

Fig. 40 is a schematic view of an astigmatism axis determination chart displayed at an astigmatism axis measurement step 2;

Fig. 41 is a view showing a state of the user at an astigmatism axis measurement step 3;

Fig. 42 is a view showing a state of the user at an astigmatism axis measurement step 4;

Fig. 43 is a schematic view of a far point distance measurement target displayed at a far point distance measurement step 1;

Fig. 44 is a view showing a state of the user at a far point distance measurement step 2;

Fig. 45 is a view showing a state of the user at a far point distance measurement step 3;

Fig. 46 is a view showing a state of the user at a far point distance measurement step 4;

Fig. 47 is a view showing a state of the user at a far point distance measurement step 5;

Fig. 48 is a view showing an example how the far point distance measurement target is viewed at a far point distance measurement step 5-1;

Fig. 49 is a view showing a state of the user at a far point distance measurement step 7;

Fig. 50 is a preparatory state for executing a near point distance measurement;

Fig. 51 is a schematic view of a near point distance measurement target displayed at a near point distance measurement step 1;

Fig. 52(A) is a view showing a state of the user at a near point distance measurement step 2, and Fig. 52(B) is a view showing a state where a target is viewed with blur;

Fig. 53(A) is a view showing a state of the user at a near point distance measurement step 3, and Fig. 53(B) is a view showing a state where a target is viewed clearly;

Fig. 54 is a view showing a state of the user at a near point distance measurement step 4;

Fig. 55 is a view showing a state of the user at a near point distance measurement step 5;

Fig. 56 is a view showing a state of the user at a near point distance measurement step 6;

Fig. 57 is a view showing a state of the user at a near

point distance measurement step 7;

Fig. 58 is a view showing a state of the user at a near point distance measurement step 8;

Fig. 59 is a schematic view of a near point distance measurement target displayed at a near point distance measurement step 9;

Fig. 60 is a view showing a state of the user at a near point distance measurement step 10;

Fig. 61 is a diagram showing an example of a configuration of an optometry system equipped for the spectacle and contact lens selecting system in an embodiment of the present invention;

Fig. 62 is a view showing an example of a process flow of the optometry system;

Fig. 63 is a view showing an example of display of a personal information entry screen;

Fig. 64 is a view showing an example of display of a wearing condition entry screen;

Fig. 65 is a view showing an example of display of an explanatory screen for astigmatism axis determination;

Fig. 66 is a view showing an example of display of an astigmatism axis determination screen;

Fig. 67 is a view showing an example of display of an explanatory screen of a far point vision test;

Fig. 68 is a view showing an example of display of a far

point vision test screen;

Fig. 69 is a view showing an example of display of an explanatory screen of near point distance measurement;

Fig. 70 is a view showing an example of a near point distance measurement screen;

Fig. 71 is a view showing an example of a configuration of a neural network for far point distance calculation;

Fig. 72 is a view showing an example of a configuration of a lens power decision system equipped for the spectacle and contact lens selecting system in an embodiment of the present invention;

Fig. 73 includes schematic views, each showing a target for testing a far point vision where (a) shows the largest target, (b) shows a medium-sized target, and (c) is the smallest target;

Fig. 74 is a schematic view showing an eyeball optical model;

Fig. 75 is a flowchart showing an operation of a corrective lens deciding server according to the present invention;

Fig. 76 is a view showing a example of a relation between a sharpness score and a view; and

Fig. 77 is a view showing a example of a screen for confirming an image viewed before and after vision correction.

DETAILED DESCRIPTION OF PRFERRED EMBODIMENTS

Fig. 1 is a view showing an example of a system configuration of a spectacle and contact lens selecting system in an embodiment of the present invention. In the drawing, the reference numeral 1 denotes a user client, the reference numeral 2 denotes a spectacle order/sales service center, and the reference numeral 3 denotes an external payment transaction agency. They are physically connected to each other via a network. In the following description, it is assumed that the network connecting the user client 1, the spectacle order/sales service center 2, and the external payment transaction agency 3 is the Internet.

The user client 1 is a terminal used when a purchaser of spectacles makes an order for sales through the network; for example, a personal computer having a network connection function is used for it. The user client 1 is an input/output device serving as an interface with the user who uses it. Although a general keyboard or mouse is used as the input device for inputting information, a dedicated input device such as a pointing device such as a track ball or a joystick, a touch panel, and a switch may be provided. As an image display device, a general CRT display or a liquid crystal monitor is used. Furthermore, this user client 2001 includes an image input device for acquiring prescription data as image information. Although a digital camera 11a and a scanner 11b

are used as the image input device, any devices capable of digitizing and inputting image information such as a video camera or a television camera may be used. The user client 1 also includes a WWW browser 12 as an interface for making an access to the spectacle order/sales service center 2 to get a service therefrom.

The spectacle order/sales service center 2 is a server for providing the user client 1 who is connected through the Internet with a service to sell spectacles fitted to a vision or in accordance with requests of each user on order; it is composed of information processing equipment such as a personal computer or a work station having a network connection function, and is connected to the user client 1 through the Internet. The spectacle order/sales service center 2 includes: electronic shop information processing means 21; display information generating means 22; spectacle order/sales processing means 23; payment transaction means 24; a WWW server/CGI 25; lens selecting means 26; frame selecting means 27; and lens power deciding means 28.

The electronic shop information processing means 21 defines item data such as spectacle lenses and frames sold by the spectacle order/sales service center 2 using an item defining section 211 through the input/output device. The item data defined herein is stored in an item database as item data information.

In this embodiment, the item data information contains: text data such as a name of a shelf on which items such as frames are displayed, an item number of a spectacle lens or frame or the like, an item name, a price, the description of an item, and item management information; image data of an item such as a frame and the like. The spectacle order/sales service center 2 also includes an input/output device as an interface with a creator of an electronic catalog. The input/output device receives the input of the item information such as text data such as a shelf name, an item category and a price that are necessary for defining an item or image data indicating a shape of an item from the catalog creator. Moreover, this input/output device outputs information containing item information such as an item number and the number of items, delivery destination information of an item, payment information such an external payment transaction agency name, a payment date, and the sum as order information of an item purchased by the user.

An electronic shop opening information database containing a shop database, an item database, and a basket database is provided for the electronic shop information processing means 21. The shop database stores information for opening an electronic shop and information for defining a shop layout to display the item information. The item database stores the defined item data information. The basket database

is for accumulating information of an item directed by the user client 1 to be purchased. The electronic shop information processing means 21 realizes a function of storing the transferred item data information in the item database.

The display information generating means 22 generates display information such as the electronic catalog in response to a request from the user client 1. The display information generating means 22 is composed so as to include parameter analyzing means 221, file search means 222, and display data generating means 223. The parameter analyzing means 221 analyzes vision test data and frame selection information and the like received from the user client 1 through the WWW server/CGI 25 so as to extract a parameter contained in the vision test data and frame selection information and the like. The file search means 222 makes a search in each database registered and stored by the electronic shop information processing means 21 based on the parameter extracted by the parameter analyzing means 221. The display data generating means 223 generates display data that can be displayed as a WWW page based on the data searched by the file search means 222. More specifically, the display data generating means 223 has a function as a so-called WWW page generator.

The spectacle order/sales processing means 23 receives a customer ID and an ID of an item to be purchased from the display information generating means 22 when the item to be

purchased (a spectacle lens, a frame or the like) is decided by the user client 1 so as to acquire detailed information of the item to be purchased from the item database based on these information. Then, it stores information of the item in a customer basket database for a target customer in the basket database. Thereafter, a list of items to be purchased by the target customer is acquired from the basket database so as to be passed to the display information generating means 22.

The payment transaction means 24 receives the customer ID from the display information generating means 22 when the item is decided to be purchased by the user client 1 so as to fetch item data information corresponding to the user from the basket database. Then, it requests the external payment transaction agency 3 to transact the payment based on the fetched item data information. The payment transaction means 24 is notified of completion of the payment transaction by the external payment transaction agency 3 so as to inform the spectacle order/sales processing means 23 and the electronic shop information processing means 21 of completion of the order process. At the same time, it creates itemization data for informing the user client 1 of a purchasing process so as to deliver the data to the display information generating means 22.

The WWW server/CGI 25 acts as an interface with the user client 1 so as to receive display request information from the

user client 1 and to transfer display data to the user client 1.

The frame selecting means 27 selects a frame desired by the user from the frames displayed in a virtual store. In this case, a frame selecting process described in a spectacle virtual try-on system described below is executed so that the user can select a frame while watching an image of the user wearing a potentially purchased frame.

The lens power deciding means 28 remotely tests a vision of the user to decide a pwoer of a corrective lens. In this case, a vision test using an eyeball optical model described for a remote subjective vision test system described below is executed so as to decide a power of a corrective lens with good accuracy.

The lens selecting means 26 selects a lens fitted to the user in consideration of the results of the vision test, a budget, the functions of a lens, and the like.

The external payment transaction agency 3 provides a payment service for the ordered spectacles in place of the spectacle order/sales service center 2 based on a request sent from the payment transaction means 24 of the spectacle order/sales service center 2.

Next, the schematic operations of the user client 1 and the spectacle order/sales service center 2 will be described.

In the spectacle order/sales service center 2, the WWW

server/CGI 25 receives spectacle order page information sent from the user client 1 so as to activate the display information generating means 22.

Upon activation, the display information generating means 22 receives the spectacle order page information from the WWW server/CGI 25 so that the parameter analyzing means 221 analyzes the received spectacle order page information. The parameter analyzing means 221 outputs information such as a shop ID for specifying an electronic shop to be displayed, a catalog template for specifying the type of a background screen of an electronic catalog, an item ID of an item to be displayed, a customer ID for identifying a user, and the like as the results of analysis. Based on these data output from the parameter analyzing means 221, the file search means 222 makes a search in the shop database, the item database, and the basket database so as to acquire data needed to create a display screen requested by the user client 1.

After the acquisition of the data by the file search means 222, the process proceeds to the display data generating means 223. The display data generating means 223 first determines the type of the request from the user client 1. If the request from the user client 1 is other than "decision of an item to be purchased" or "purchase of an item," the display data generating means 223 uses the results of a search to create data for display by the file search means 223.

As a result of determination at the step of determining the type of the request from the user client 1, if the type of the request from the user client 1 is "determination of an item to be purchased," that is, if the customer directs to "add a selected item into the shopping basket" so as to indicate that the displayed item will be purchased, the display data generating means 223 activates the spectacle order/sales processing means 23.

Upon activation, the spectacle order/sales processing means 23 receives the customer ID and the item ID of the item directed to be purchased by the customer from the display data generating means 223. Then, it acquires detailed item data information for the corresponding item from the item database using the item ID as key information. Then, the item data information acquired at the above-described step is stored in the customer basket database of the customer identified by the customer ID received from the display data generating means 223 in the basket database. At this time, if the corresponding customer basket database does not exist, a customer basket database corresponding to the customer ID is created so as to store the item data information therein. Furthermore, it fetches out all the item data information selected by the user by then from the customer basket database so as to deliver it to the display data generating means 223. In this case, the display data generating means 223 creates list display

information of items to be purchased by the customer from the item data information received from the spectacle order/sales processing means 23 so as to send it to the user client 1. The customer can confirm the items to be purchased or cancel a part of or all of the items to be purchased based on the information displayed at this time.

As a result of determination at the step of determining the type of the request from the user client 1, if the type of the request from the user client 1 is "purchase of an item," that is, if the customer directs the decision of purchase of the items selected by then, the display data generating means 223 activates the payment transaction means 24 prior to creation of display data.

Upon activation, the payment transaction means 24 receives the customer ID from the display data generating means 223. The payment transaction means 24 searches the item data information of the items to be purchased, which is stored in the customer basket database of the customer identified by the customer ID from the basket database. Based on the item data information obtained as a result of the search, the external payment transaction agency 3 is requested to make a payment transaction. In response to this request, the external payment transaction agency 3 provides a payment transaction service in place of the spectacle order/sales service center 2 and then notifies the spectacle order/sales service center 2

of completion of the payment transaction at its completion. Since the payment transaction carried out by the external payment transaction agency 3 is not particularly different from a conventional one, the detailed description thereof is herein omitted.

When the payment transaction means 24 is notified of the completion of the payment transaction from the external payment transaction agency 3, it transfers order information including information related to the ordered item such as an item number and the number of ordered items, delivery destination information indicating destination of the item, and payment information consisting of a name of the external payment transaction agency 3 executing the payment transaction, a payment date, sum information and the like to the spectacle order/sales service center 2. In the spectacle sales service center 2, the order information received from the WWW server/CGI is displayed by the input/output device. Finally, the payment transaction means 24 creates itemization data for notification of the completion of the payment transaction and passes it to the display data generating means 223. The display data generating means 223 uses the received itemization data to create a display screen for notification of the completion of the payment transaction and then to transfer it to the user client 1.

Next, a method of ordering and selling spectacles by the

spectacle and contact lens selecting system will be described below.

Fig. 2 is a view showing the schema of a process when the user purchases spectacles or contact lenses. As illustrated, if the user wants to select a frame, a frame is selected; if the user wants to test his/her vision, an uncorrected vision and a corrected vision are tested. If the user wants to select a lens, a lens is selected. In response to notification of payment in advance or part payment from the payment transaction, spectacles or contact lenses are processed or assembled based on the information of the selected frame and the selected lenses and the result of the vision test. Then, the item is delivered to the user cash on delivery. Although the process is herein described as proceeding in the order of the selection of a frame, the vision test, and the selection of a lens, it is sufficient to carry out only the processes needed by a request of the user and the order thereof may be arbitrary. For example, a vision may be first tested. Then, a lens may be selected, and a frame may be selected at the final step. If the user only wants to change a lens power, only a vision test may be carried out so that a lens or a frame can be selected based on the customer database. If the user only wants to replace a frame, only a frame may be selected so that a vision may be determined or a lens may be selected based on the customer database.

Figs. 3 to 8 show the schema of the process of the spectacle and contact lens selecting system. Fig. 3 is a view showing the schema of a process for first categorizing the user; Fig. 4 is a view showing the schema of a process in the case where the user is a returning customer; Fig. 5 is a view showing the schema of a process in the case where the user is not a customer but has a prescription; Fig. 6 is a view showing the schema in the case where the user is not a customer, does not have a prescription, and is not destined to wear a pair of spectacles for presbyopia; Fig. 7 is a view showing the schema in the case where the user is not a customer and does not have a prescription with no subjective symptom of presbyopia; and Fig. 8 is a view showing the schema in the case where the user prefers a pair of ready-made spectacles for presbyopia.

First, when the spectacle order/sales service center 2 accepts the connection from the user client 1, it transmits basic attribute entry screen for prompting input of basic attributes such as a name, the date of birth and a telephone number. The user client 1 receives and displays the basic attribute entry screen so as to transmit the basic attributes input by the user to the spectacle order/sales service center 2. The spectacle order/sales service center 2 receives the input basic attributes so as to search the customer database by the spectacle order/sales processing means 23.

If it is determined that the user is a customer who has already purchased spectacles as a result of the search, the process proceeds to Fig. 4 where an inquiry screen for confirming the intension of the user is transmitted to the user client 1. If the user selects "I select the same lenses as the previous ones and the same frame as the previous one" on the inquiry screen, lenses are created based on the vision test data, the frame information data, and the lens information data managed by the customer database (basket database). If the user desires to get new lenses and/or a new frame on the inquiry screen, a step selecting screen for transition to a "lens power deciding step," a "frame selecting step," and a "lens selecting step" is transmitted to the user client 1. If the user selects "I don't want the same lens power as the previous one" on the selection screen, the "lens power decision step" is carried out. If "I select new frames," the "frame selecting step" is carried out. If "I select new lenses," the "lens selecting step" is carried out. At the "lens power deciding step" in this case, a "remote vision test system" described below is carried out. At the "frame selecting step", an inquiry screen for making an inquiry whether a spectacle wearing virtual try-on is carried out or not is transmitted to the user client 1. If the user selects "I try the spectacles on," the "spectacle virtual try-on system" is carried out.

If he/she is not a customer, a prescription confirmation screen for making an inquiry whether he/she has a prescription from an ophthalmologist or not is transmitted to the user client 1. If the user selects "I have a prescription from a doctor" on the prescription confirmation screen, the process proceeds to Fig. 5 where a prescription entry guidance screen is transmitted to the user client 1. The user inputs the prescription as image data from a scanner in accordance with the guidance of the screen or as text data from the keyboard so as to transmit it to the spectacle order/sales service center 2. Then, as in the above-described case, the step selecting screen for the transition to the "lens power deciding step," the "frame selecting step," and the "lens selecting step" is transmitted to the user client 1 so as to execute each of the processes in response to the request of the user.

If the user selects "I don't have a prescription," an inquiry screen for making an inquiry whether the age of the user exceeds 40 through 45 years old or not is transmitted to the user client 1. If the user selects "I am 40 through 45 years old or below" on the inquiry screen, the process proceeds to Fig. 6 where the step selecting screen for transition to the "lens power deciding step," the "frame selecting step," and the "lens selecting step" is transmitted to the user client 1 so as to execute each of the processes in

response to the request of the user.

If the user selects "I am older than 40 through 45 years old," an inquiry screen whether he/she has the subjective symptom that he/she cannot clearly see the vicinity of his/her hands or not is also transmitted to the user client 1. If the user selects "I don't have any subjective symptoms" on the inquiry screen, the process proceeds to Fig. 7 where the step selecting screen for transition to the "lens power deciding step," the "frame selecting step," and the "lens selecting step" is transmitted to the user client 1 so as to execute each of the processes in response to the request of the user. In this case, since there is a possibility that he/she may be presbyope in view of the age of the user, a "step of selecting the type from longsightedness, shortsightedness and bifocals" is executed.

If the user selects "I have a subjective symptom," the spectacle order-sales service center 2 determines that the user is presbyope and transmits an inquiry screen for asking if he/she prefers custom-made spectacles for presbyopia or not to the user client 1. If the user selects "I prefer custom-made spectacles" on the inquiry screen, the process proceeds to Fig. 7 where the step selecting screen for transition to the "lens power selecting step," the "frame selecting step," and the "lens selecting step" is transmitted to the user client 1 to execute each of the processes in accordance with

the request of the user. In this case, the "step of selecting from spectacles for longsightedness, shortsightedness, and bifocals" is further executed.

If the user selects "I prefer ready-made spectacles for presbyopia," the process proceeds to Fig. 8 so as to decide a lens power determined from the age of the user and then to transmit the step selecting screen for transition to the "frame selecting step" and the "lens selecting step" to the user client to execute each of the processes in response to the request of the user.

Although it is described in the above process that the basic information of the user is first input, a user ID and a password may be issued to the user who has registered the basic information in advance so as to enter the user ID and the password when the user connects from the user client 1 to the spectacle order/sales service center 2 for authentication. In this case, it can be determined based on the user ID whether the user is a customer who has already purchased spectacles or not.

Next, a way of providing a service will be specifically described by using an example of a screen displayed on the user client 1.

First, the spectacle order/sales service center 2 first transmits a screen at the top of a site (Fig. 11) to the user client 1 and subsequently transmits a personal computer screen

information collecting screen (Fig. 12) to the user client 1 so as to instruct the purchaser to enter display (monitor) information such as a resolution and size of the personal computer screen, thereby acquiring the display information input by the user client 1.

Next, on a service selecting screen (Fig. 13) transmitted from the spectacle order/sales service center 2, the user clicks any one of the "remote subjective vision test step (World first! Self-check spectacle lens power identification system)," the "frame selecting system (Try various spectacles on! Frame fitting room)," the "lens selecting step (Use lenses without vision correction)," and the "prescription supply step (Use prescription data from an ophthalmologist or data of a spectacle store card)" so as to transmit the intension of the user from the user client to the spectacle order/sales service center 2.

When selection criteria of lenses become clear at the remote subjective vision test step or the prescription supply step, the process proceeds to the lens selecting step.

Next, the lens selecting step will be described.

When the user decides to use the most recent vision data and therefore clicks "Select the same lenses as the previous ones," when the user decides to have spectacles made based on prescription data from a doctor and therefore clicks "Select lenses in accordance with the prescription," or when the user

determines to purchase ready-made spectacles for presbyopia and therefore clicks "Select ready-made spectacles for presbyopia," the lens selecting means 26 selects lenses based on the respective data.

If the user wants to remotely test his/her vision even though he/she has the most recent vision data or a prescription from a doctor, the user proceeds to the remote vision test step by the vision deciding means 28 so as to test his/her vision.

Although various lenses are registered as a database (Figs. 9 and 10) in the spectacle order/sales service center 2, the lens selecting means 26 transmits a lens selection screen, on which a lens satisfying the request of the user input from the user client 1 or a lens recommended by the spectacle order/sales service center 2 to the user is displayed from them, to the user client 1 based on the most recent vision data, the prescription from a doctor, or data obtained by testing with the remote vision test system. Moreover, if the user is a returning customer, the previously purchased lenses are also displayed on the lens selection screen.

As choices in the selection of lenses, a manufacturer name, a model, a purpose of use, lens functions (a lens thickness, a lens weight, endurance, UV protection), a color, a price, and a lens power and the like. The user specifies these options to search a lens, selects a lens that he/she

wants to purchase, and transmits it to the spectacle order sale service center 2.

Next, the frame selecting step will be described.

For example, if data regarding frame functional and decorative aspects is present in the spectacle order/sales service center 2 as in the case where he/she is a returning customer, a frame can be specified in view of fashion, image, design and the like.

The frame selection in the case where the frame data in terms of functions and decoration is present in the spectacle order/sales service center 2 will be described below.

Frames are registered in the spectacle order/sales service center 2 as a database. The frame selecting means 27 transmits a frame selection top screen (Fig. 14), on which typical frames among them are displayed, to the user client 1. Then, the user answers questions in the form of questionnaire about fashion, a material, design, a budget, and the like so that the frame selecting means 27 selects a frame which seems to be the most suitable based on the data indicating the intensions of the user and transmits a frame selection screen to the user client 1.

The frame selection screen categorizes the spectacle frames in accordance with gender/material and displays typical frame images falling within the category.

If he/she is a returning customer, the previously

purchased frame is also displayed on the frame selection screen.

As choices of a frame, there are fashion, a material, design, a price, and the like. The user reads the options to enter the desired conditions, selects a frame that he/she wishes to purchase from the displayed frame images, and transmits it to the spectacle order/sales service center 2.

At this time, this system is equipped with wearing state display means of virtually putting the selected frame on a model's face or his/her own face.

Next, an embodiment of the wearing state display means constituting the present invention will be described using a spectacle virtual try-on system shown in Fig. 25.

The spectacle virtual try-on system realizes a virtual experience that various spectacle frames can be put on a face of a model or the user, and is constituted by a user client 2001 and a spectacle order/sales service center 2002. The user client 2001 and the spectacle order/sales service center 2002 are physically connected through a network. In this case, the following description will be given assuming that the network is the Internet.

The user client 2001 is a terminal used when the user virtually tries spectacles on, and is composed of, for example, a personal computer having a network connection function. Although a general CRT display or liquid crystal monitor is

used as an image display device for displaying a spectacle wearing state, a dedicated image display device such as a head mount display (HMD) or a projection-type display device may be prepared. Moreover, although a general keyboard or mouse is used as an input device for inputting information such as frame selection information, a dedicated input device such as a pointing device such as a track ball and a joystick, a touch panel, and a switch may be prepared. Furthermore, this user client 2001 includes image input means for acquiring a facial image of the user. Although a digital camera is used in this case, any devices capable of digitizing and inputting an image such as a video camera and a scanner may be used. Furthermore, the user client 2001 includes a WWW browser as an interface for making an access to the spectacle order/sales service center 2002 so as to receive a service therefrom.

The spectacle order/sales service center 2002 is a server for providing a spectacle virtual try-on service; it is composed of information processing equipment such as a personal computer and a work station which has a network connection function, and is connected to the user client 2001 through the Internet. The spectacle order/sales service center 2002 includes a WWW server serving as a contact point for providing a service to the user client 2001. Moreover, it includes: user information registering means 2003 for registering user information including a facial image of the

user; frame selection information input means 2004 for inputting selection information at the selection of a frame by the user; database management means 2005 for conducting access management to the database; frame information registering means 2060 for registering the functional structures and the decorative structures of frames to be sold; frame image registering means 2061 for registering the images of frames to be sold; image synthesizing means 2007 for synthesizing a frame image and a facial image of a model or the user; and frame selecting means 2008 for selecting a corresponding frame based on the frame selection information. It is connected to the WWW server through input means 2006 and output means 2009. Each of the means is activated by a CGI of the WWW server as needed so as to provide a spectacle virtual try-on service to the user client 2001. Moreover, the WWW server has a user authentication function for authenticating that the user client 2001 is a legitimate user.

The database managed by the database management means 2005 includes a user information database, a frame selection information database, a frame functional structure database, and a frame decorative structure database as shown in Figs. 26 to 29.

Next, a process procedure for providing a spectacle virtual try-one service by this system to the user will be described.

First, a service provider activates the frame information registering means 2060 to input functional structure data and decorative structure data of spectacles to be sold by the keyboard and the like so as to register them on the databases.

As shown in Fig. 28 the frame functional structure data of each frame includes a size or an actual size (44Ø - 62Ø), and features such as a shape-memory alloy, super-light weight, super-elasticity, simultaneous function as sunglasses, portability and so forth. Also included are functions such as the distance between the right and left pupils, the widths from the center of the right and left pupils to the feet of the ears, the opening angles of temples determined based on the widths from the center of the right and left pupils to the feet of the ears, the distances from the feet of the ears to the tops of the corneas, the bending positions of the temples, the distances between the tops of the corneas and the foot of the nose, and the opening angles of pad bridges determined based on the distances between the tops of the corneas and the foot of the nose. As shown in Fig. 29, the frame ornamental structure data includes as shapes such as Wellington, Lloyd, Oval, Square, Tonneau, Boston, Butterfly, and Auto (Drop). Materials are rimless (two-point, three-point), metal + nylon rimmed, celluloid + nylon rimmed, metal, celluloid, brow-line, combination and so forth. Brands include various brands, and colors include various colors.

The frame image registering means 2061 is also activated to input images of the frames of spectacles to be sold from the scanner or the like so as to register them on the database.

Next, when the user makes an access to the WWW server by using the WWW browser of the user client 2001, the WWW server transmits a user authentication screen. The user authentication screen instructs an input of user authentication information such as a user ID and a password. If the user authentication has already been completed at the previous step, it is not required to be executed again and therefore is skipped.

The database management means 2005 makes a search in the user information database by the input user authentication information so as to execute the authentication.

If a service is provided for the user for the first time, the user information registering means 2003 is activated to transmit a basic attribute entry screen to the user client 2001. After the user enters the user's basic attributes, for example, name, address, date of birth, telephone number, eye function (he/she cannot clearly see the area around his/her hands or the like), requirements for spectacles and the like in accordance with the screen, a user ID and a password are issued to the corresponding user so that the received basic attribute information of the user is registered on the user information database.

At the completion of the user authentication, the frame selection information input means 2004 is activated so that a frame selection information entry screen serving the user to input frame selection information is transmitted to the user client 2001. The frame selection information entry screen is for inputting criteria (fashion, a budget, functions, fitness to the face and the like) for selection of a frame by the user. The user inputs frame selection criteria such as fashion, a budget, functions, and the fitness to the face on the frame selection information entry screen.

Next, a PD measurement screen (Fig. 15) is transmitted to the user client 2001 for measurement of the position of a pupil so that the pupil is positioned at the center of a lens.

When the entry of the frame selection criteria in the text data and the PD measurement are completed, a facial image selection screen (Fig. 16) for asking "On which face do you want to try frames?" is transmitted. If the user selects "Use a model face," the process proceeds to a next virtual frame selection screen. If the user selects "Use my self-portrait," a self-portrait upload screen (Fig. 17) is transmitted.

On the self-portrait upload screen, a screen for asking "Where is your picture data?" is transmitted so that the user selects either "Use digital camera picture data" or "Use picture data obtained by a scanner." The user fetches front and lateral (both on the right and left sides) facial images

into the user client 2001 by the image input device so as to transmit them to the spectacle order/sales service center 2002.

The frame selection information input means 2004 receives the text data of the frame selection information and the image data (the facial images of the user) transmitted from the user client 2001 so as to register necessary information on the frame selection information database in the following manner.

(1) Based on the side images (Fig. 30) of the user, the distances (L_1) between the feet of the ears and the tops of the corneas of the user are measured separately for the left and right, and the resulting data is registered. Based on the aforementioned measurements, the positions at which the temples are bent are determined separately for the left and right, and then registered.

(2) Based on the side images of the user, the distances (L_2) between the tops of the corneas of the user eyes and the foot of the nose are measured, and an average value of the left and right distances is registered. The distance L_2 is usually 12mm. Based on the above measurements, the opening angles of the pad bridges are determined and registered.

(3) Based on the front image (Fig. 31) of the user, the widths (L_3) from the center of the pupils of the right and left eyes to the feet of the ears are measured separately for the left and right, and are then registered. Based on the above measurements, the opening angles θ of the temples are

determined separately for the left and right and are registered.

For the widths from the center of the pupils of the right and left eyes to the ears, the distance between the pupils (PD) is first determined. However, the pupils cannot be precisely detected on the user face image, and therefore the distance between the pupils (PD) is approximated, for example, from the distance (PD_1) between the left side of the left eye and the left side of the right eye.

The pupils cannot be detected from the face image. Therefore, to determine the distance (L_4) between the pupil of the left eye and the left ear, the distance from the foot of the left ear to the right side of the left eye (L_a) and the distance from the foot of the left ear to the left side (L_b) of the left eye are determined. Then, the distance (L_4) between the pupil of the left eye and the left ear is determined by calculating an average of them. The distance between the right eye and the right ear can also be determined in the same manner.

The opening angles θ of the left and right temples of the spectacle frame are adjusted, for example, by correcting and bending the temples by the amount of angle obtained from the following equation.

$$PD/2 + L_4 - L_5$$

where L_5 is the front size of the spectacle frame (Refer

to Fig. 32).

(4) When bifocal lenses are specified, an additional bending angle of 5 degrees is provided for the angle of inclination of the lens surface. For this reason, the opening angle of the pad bridges is determined and registered by being corrected with the additional angle of bending.

Thus, the frame selection information input means 2004 perform computation to create functional structure data, ornamental structure data, and face image data, which are in turn stored by the database management means 2005 in conjunction with the face image data.

At the spectacle order/sales service center 2002, the frame information registering means 2060 and the frame image registering means 2061 store in advance the frame functional structure, the frame ornamental structure, and the frame image of each frame. An appropriate frame is selected corresponding to the functional structure data, ornamental structure data, and face image data according to the frame selection criteria transmitted from the user client 2001.

After the selection of several types of frame conforming to the frame selection information by the frame selecting means 2008, the virtual frame selection screen (Fig. 18) is transmitted to the user client 2001. On the virtual frame selection screen, "Try various frames and save the ones you like (up to four frames) for now" is displayed so as to

instruct the user to select frames that interest him/her. As a result, the user can virtually try the selected frames on so as to save frames that interest him/her for now in view of the results of virtual try-on.

On the virtual frame selection screen, there are "material and price range," "material and brand," "material and price range and brand," and the like as search criteria. As choices for material, "Plastic," "Metal," "Two-point," "Nairoll," "Combination," "SG," and the like are displayed so that a selection can be made from them. As choices of price range, "5000 to 9999 yen," "10000 to 14999 yen," "15000 to 19999 yen," "20000 to 30000 yen," and the like are pull-down displayed so that a selection can be made from them. As choices of brand, various brand names are pull-down displayed so that a selection can be made from them. The number of frames which are allowed to be saved is four at maximum. If the number exceeds it, the frames are appropriately reselected so as to put the unnecessary ones into a dust box to delete them.

An image of each of the selected frames is resized and synthesized so as to fit to the facial image of the user by the image synthesizing means 2007 to generate a spectacle wearing image. Then, the generated spectacle wearing image is transmitted to the user client 1 as a part of the virtual frame selection screen (Fig. 18). At this time, lateral images

of the frame may be simultaneously displayed. Furthermore, a spectacle wearing image obtained by synthesizing the image and the lateral images of the user may be generated and displayed by the image synthesizing means 2007. As a result, the user can confirm the fitness on the lateral faces of the frame.

If "See a different color" is selected on the virtual frame selection screen, a different color display screen (Fig. 19) is transmitted to the user client 2001. On the different color display screen, all different colors of the same model are displayed to show items in different colors. If the number of frames in different colors is less than 8, a field is displayed as a blank.

The user sees a spectacle wearing image displayed on the user client 2001 so as to confirm if the selected frame meets his/her requirements and the face with the frame on.

If an image of a frame different from the desired one is transmitted or it is desired to see the face with another frame in this case, the user specifies the frame selection information again so as to transmit it to the spectacle order/sales service center 2002. As a result, another frame is selected by the same method as that described above. A spectacle wearing image obtained by synthesizing an image of the frame selected by the user and the facial image is generated by the image synthesizing means 2007 so as to be transmitted to the user client 2001 again.

Next, in order that the user confirms the frames saved on the virtual frame selection screen (Fig. 18) and the different color display screen (Fig. 19), a saved-item confirmation screen (Fig. 20) is transmitted to the user client 2001. On the saved-item confirmation screen, "Confirm the saved frames and select the one that I want to purchase" is displayed. As a result, a frame can be selected simultaneously with a virtual experience.

If the user purchases the frame confirmed through the virtual experience with color lenses, a predetermined part is clicked.

Next, a purchased frame confirmation screen (Fig. 21) is transmitted to the user client 2001 so as to instruct the user to confirm the type of frame and the type of lenses to be purchased. On the purchased frame confirmation screen, an image with the selected frame on, the type of frame and the type of color lenses are displayed. If he/she does not need an item, he/she clicks "Cancel." If he/she purchases them, he/she clicks "Buy."

If "Buy" is selected on the purchased frame confirmation screen, a lens power selection screen (Fig. 22) for having spectacles made is transmitted to the user client 2001. On the lens power selection screen for getting spectacles, the question "Which lens power data do you use for the spectacles on this order?" is given. As choices, "Use lens power data

tested on this site," "Use lenses without vision correction," and "Use prescription data from an ophthalmologist or data of a card from a spectacle store" are displayed so as to instruct the user to make a selection from the "lens power deciding step," the "lens selection step," and the "prescription supply step."

If "Use prescription data from an ophthalmologist or data of a card from a spectacle store" is selected, the process proceeds to the "prescription supply step" so as to transmit a prescription data entry screen (Fig. 23) to the user client 2001. On the prescription data entry screen, "Enter a lens power" is displayed so as to instruct the following input.

· PD (in mm)

· Right eye S (pull-down display of lens power data: +0.25, -0.25, -0.50, -0.75, -1.00 and the like), C, AX (pull-down display of astigmatism axis data: 180° ± 22.5°, 135 ± 22.5°, 90 ± 22.5°, 45 ± 22.5°, 0 ± 22.5° and the like)

· Left eye S (pull-down display of lens power data: +0.25, -0.25, -0.50, -0.75, -1.00 and the like), C, AX (pull-down display of astigmatism axis data: 180° ± 22.5°, 135 ± 22.5°, 90 ± 22.5°, 45 ± 22.5°, 0 ± 22.5° and the like)

If "Use lenses without vision correction" is selected on the lens power selection screen for getting spectacles and if the prescription data is input on the prescription data entry screen, a lens thickness comparison screen (Fig. 24) is

transmitted to the user client 2001. On the lens thickness comparison screen, "Which lenses do you want for the spectacles? Thickness is displayed in accordance with your lens power" is displayed to display cross-sectional shapes and lens prices for a "standard lens," a "thin lens," and a "thin lens without distortion" so that the user can compare the thicknesses of the lenses.

When the frame is selected, the process proceeds to the payment system.

As described above, according to the spectacle virtual try-on system, the user can put various spectacle frames on the picture data. In addition, he/she can try various spectacle frames on at home through a network such as the Internet without going to a store so as to select the most suitable frame meeting his/her own preferences. Moreover, according to this system, since he/she can confirms himself/herself with the selecting spectacle frame on while wearing his own spectacles or contact lenses, that is, with proper vision, a spectacle frame optimal for him/her can be selected.

In the above-described embodiment, the spectacle virtual try-on system, which allows various spectacle frames to be put on the picture data of the user as the wearing state display means, has been described. However, not only a spectacle frame but also contact lenses may be virtually tried on by using

similar image synthesizing means. In particular, with color contact lenses and the like on, the image of the face greatly changes. Therefore, if the image when wearing them can be confirmed, the user is assured to select contact lenses.

Next, a first preferred embodiment of lens power determination step is explained below by using a remote subjective vision measurement system as shown in Fig. 33. As illustrated, the remote subjective vision measurement system 10 comprises hardware of user clients 4001 and a spectacle order/sales service center 4002. These are physically connected to each other via networks. The following descriptions will be given assuming that the network connecting between the user clients 4001 and the spectacle order/sales service center 4002 is the Internet.

A user client 4001 is a terminal used when the user receives a vision test service. Like the above-described user client 1, a personal computer having an Internet connection function and the like is used as the user client.

A spectacle order/sales service center 4002 is a server for providing a vision test service and is composed of information processing equipment such as a personal computer, a work station, and the like having a network connection function so as to be connected to the user client 4001 through the Internet.

The spectacle order/sales service center 4002 includes a

WWW server 4030 serving as a contact point for providing a service to the user. Moreover, it includes eyeball optical model deciding means 4204, model validity examination means 4206, eyeball optical dimensions-accommodation range determination means 4208, eyeball optical model image generating means 4210, eyeball optical model focal performance examination means 4212, viewed image generating means 4214, sharpness score generating means 4216, lens power selecting means 4218, user information management means 4230, and database management means 4232. It is connected to the WWW server 4030 through input means 4202 and output means 4220. Each of the means is activated by a CGI of the WWW server as needed so as to provide a vision test service to the user client 4001. Moreover, the WWW server has a user authentication function for authenticating that the user client 4001 is a legitimate user.

The input means 4202 inputs information of eyes of a subject such as wearing conditions of the subject, age, a near point distance, a far point distance, and the like.

The eyeball optical model deciding means 4204 is designed to determine a start eyeball optical model in accordance with the age of a subject and information on the eye such as the approximate lens power. The eyeball optical model deciding means 4204 is designed to determine an eyeball optical model in accordance with such eyeball optical dimensions that the

focal state of the eyeball of a subject is optimized at the accommodation midpoint calculated from the near point distance and the far point distance of the subject.

The model validity examination means 4206 further examines the validity of the eyeball optical model at the accommodation limit on the near point side and/or the far point side.

The eyeball optical dimensions-accommodation range determination means 4208 is constituted so as to determine the range of accommodation of an eyeball at an accommodation midpoint, and in addition displays an image of an eyeball optical model, in which the range of accommodation of the eyeball at the accommodation midpoint is determined.

The eyeball optical model focal performance examination means 4212 examines a focal state of the eyeball optical model at a near point or a position within the range of accommodation ability in the vicinity of the near point, at a far point or a position within the range of accommodation ability in the vicinity of the far point, or a position away from the near point and the far point in a naked eye state of the subject. Furthermore, the eyeball optical model focal performance examination means 4212 examines a focal state of the eyeball optical model of the subject at a near point or a position within the range of accommodation ability in the vicinity of the near point, at a far point or a position

within the range of accommodation ability in the vicinity of the far point, or a position away from the near point and the far point after vision correction with spectacles or contact lenses.

The viewed image generating means 4214 generates visual images viewed by the subject before and/or after the correction by means of a spectacle or contact lens.

The sharpness score generating means 4216 derives the sharpness score of the viewing by the subject before and/or after the correction by means of a spectacle or contact lens.

The lens power selecting means 4218 examines optical performance when the subject wears spectacles or contact lenses so as to select a lens power.

Next, a method of testing a vision by using this remote subjective vision test system will be described in accordance with a flow of Figs. 34 and 35.

After the user client 4001 makes an access to the spectacle order/sales service center 4002 to complete the user authentication, a guidance screen is transmitted to the user client 4001 so as to be displayed.

Next, a personal computer screen information collecting screen (Fig. 36) is transmitted to the user client 4001. On the personal computer screen information collecting screen, "Give us your personal computer information; necessary to get spectacles fitted to your eyes" is displayed so as to instruct

the entry of display information such as a resolution. Then, "How long is this line in centimeters on your monitor screen?" so as to instruct the entry of size of the display.

Next, a user information entry screen (Fig. 37) is transmitted to the user client 4001. On the user information entry screen, the user is instructed to enter user information and data as information identifying the user. The user information includes base attributes such as a user code, a user identifier (ID), a user password, address, name, the date of birth, and telephone number, and data include the purpose of use, a near point distance, a far point distance, age, the previous lens power, vision of both eyes at the previous lens power, the balance of the right and left eyes at the previous lens power, how many years the previous spectacles are used, the type of contact lenses (if also used), desired corrected vision, and a disease related to vision. After the entry of the personal information, a wearing condition entry screen (Fig. 38) is transmitted to the user client 4001. As wearing conditions, the purpose of wearing spectacles or contact lenses (the situations in which he/she wants to wear them, for example, to see the area around his/her hands, to see objects in the distance and to drive a car and the like) or a visual environment (at which distance and in which area he/she often see objects in daily life, if she/he has much work on a personal computer as business activity, and the like).

Next, an uncorrected vision test screen is transmitted to the user client 4001.

An uncorrected vision test is executed in the order of astigmatism axis measurement, a far point vision test, and a near point vision test. Although a measurement method of estimating a far point distance by the measurement at a certain distance (at a distance equal to a length of a human arm) is used in this embodiment, a method of directly measuring a far point distance may also be used.

The astigmatism axis measurement is performed in the following procedure.

An astigmatism axis measurement step 1: First, a guidance screen is transmitted (Fig. 39) to display "Follow the following instructions. The right eye is measured. First, four zones hatched with parallel lines are displayed. Move about 1 m away from the screen and then come up to the position where you can clearly see the lines of any one of the four zones. Remove the spectacles or the contact lenses at this step. When watching a displayed target, cover your left eye with a hand so as not to touch the eye."

An astigmatism axis measurement step 2: Next, an astigmatism axis measurement screen is transmitted so as to display an astigmatism axis determination chart composed of four patterns on the screen (Fig. 40).

An astigmatism axis measurement step 3: At this step, the user

moves away about 1 m while covering the left eye with the left hand. At this time, the left eye is kept open. A state of the user at this step is shown in Fig. 41.

An astigmatism axis measurement step 4: Next, the user brings his/her face gradually closer to the screen and stops at a distance allowing the distinction of four patterns. He/she should be careful not to be too close. A state of the user at this step is shown in Fig. 42.

An astigmatism axis measurement step 5: At this step, it is determined whether the four patterns in the drawing appear the same to the user or any one of them appears darker or brighter.

An astigmatism axis measurement step 5-1: If "One of them appears dissimilar," the corresponding pattern is clicked.

An astigmatism axis measurement step 5-2: If "All zones viewed equally well" or "Indistinguishable," the comment below the patterns is clicked.

An astigmatism axis measurement step 6: Subsequently, the right eye is covered with the right hand so as to execute the same process for the left eye.

An astigmatism axis determination chart is composed of linear groups in four directions, at 45 degrees, 90 degrees, 135 degrees, and 180 degrees, each being formed by a plurality of parallel lines as shown in Fig. 40. If the subject is astigmatic, he/she has a clear view in a certain direction but the zone appears as if were compressed and paled in another

direction. Therefore, he/she is instructed to click the zone which appears dissimilar. The reason why the direction in which a view is different is selected is because the direction giving a clear view for an astigmatic may possibly be reversed at 90 degrees, depending on a distance to the object. Therefore, there is a possibility that the axis of astigmatism is erroneously determined if the direction giving a clear view is determined first. Accordingly, in the present invention, the principal axis of astigmatism is not determined yet at this step. At a later step of obtaining a far point distance, two far point distances calculated by targets in two directions are compared with each other so that the direction with a longer distance is determined as the principal axis.

Since the subject who is not astigmatic should principally has a uniform view in all the directions, the subject who clicks "All zones viewed equally well" or "Indistinguishable" is regarded as non-astigmatic so that the following measurement is performed only for horizontal and vertical principal axes.

In the case where a resolution of the determination of axis of astigmatism is desired to be enhanced, linear groups in four directions at intermediate angles between the respective four directions, that is, at 22.5 degrees, 67.5 degrees, 112.5 degrees, and 157.5 degrees may be added and displayed for selection.

Next, a far point distance is measured. Primarily, the far point distance measurement examines how long the subject can position away from a screen, watching the screen in a comfortable manner. He/she stops the face at the farthest position at which he/she can see without blur (the position at which the screen starts being blurred). A distance measured from the screen to the eye corresponds to a far point distance. However, since there is a limit in moving away from the personal computer, the far point distance is calculated by measuring a far point vision at a certain distance in this case.

The far point vision is measured by determining the limit of size of an object that the user can see at a certain distance. The far point vision in this embodiment does not mean a generally used power unit such as 1.5 but another numerical unit. Hereinafter, the far point vision will be described in detail. The subject perfectly stretches out his/her arms while touching a display with fingers. He/she perfectly stretches out the arms with the ramrod-straight posture. In this state, targets for measuring the far point vision are displayed on the display as shown in Fig. 43. The subject selects the smallest one of the displayed targets, of which black three lines he/she can clearly see. The number assigned to the target selected by the subject is determined as the far point vision. The far point distance is calculated

from the far point vision based on the size of the target and the distance from the screen.

The far point vision is measured in the following procedure.

A far point distance measurement step 1: A far point distance measurement screen is transmitted so that a screen on which far point distance measurement targets, each being different in size with three vertical lines, are in a set is displayed (Fig. 43).

A far point distance measurement step 2: At this step, the user touches the edge of the personal computer screen with the middle finger while perfectly stretching out the right arm to the fingertips. A state of the user at this step is shown in Fig. 44.

A far point distance measurement step 3: Next, the user covers the left eye with the left hand so as to see the far point distance measurement targets with the right eye. A state of the user at this step is shown in Fig. 45.

A far point distance measurement step 4: Next, the user sees a far point distance measurement chart displayed on the screen with the ramrod-straight posture in this state. A state of the user at this step is shown in Fig. 46.

A far point distance measurement step 5: At this step, it is determined whether the user can recognize three lines in the image or not. A state of the user at this step is shown in Fig.

47.

A far point distance measurement step 5-1: If the user cannot recognize three lines in any one of them, he/she clicks "YES." If the user recognizes three lines (even in the case where they are "blurred"), he/she clicks "NO." The criterion of recognition of the three lines is, for example, as shown in Fig. 48.

A far point distance measurement step 5-2: At this step, if the user answers "NO," the far point measurement targets are displayed in the smaller order so as to repeat a check until the image of which three lines are recognized appears.

A far point distance measurement step 6: Subsequently, the chart on the screen is changed to display far point distance measurement targets, each with three horizontal lines, so as to direct the measurement (not shown).

A far point distance measurement step 7: Similarly, the user sees the far point distance measurement targets with the right eye while covering the left eye with the left hand so as to carry out the same check. A state of the user at this step is shown in Fig. 49.

The check for the right eye is completed at this step.

A far point distance measurement step 8: Next, the left eye will be checked. As for the right eye, the user touches the edge of the personal computer screen with the middle finger while perfectly stretching out the left arm to the fingertips.

He/she covers the right eye with the right hand to see the far point distance measurement targets with the left eye so as to carry out a check for the left eye in the same manner as for the right eye.

Although the far point distance is measured with the targets, each with three vertical lines, and the targets, each with three horizontal lines, in the above description, the measurement is performed in the direction selected by the above-described astigmatism axis measurement and the direction perpendicularly crossing it. If the user is oblique astigmatic, the far point distance should be measured in two directions at 45 degrees and 135 degrees.

Although the screen, on which the targets of all sizes are combined, is first displayed so that the targets are then displayed in the smaller order in the above description, the present invention is not limited thereto. The targets may be individually displayed from the beginning. On the screen on which a plurality of targets are combined, the smallest target whose three lines can be recognized may be selected and clicked.

Next, a near point distance is measured. The near point distance measurement examines how close the subject can get to the screen while watching the screen in a comfortable manner. He/she stops the face at the nearest position at which he/she can see without blur. A distance measured between the screen

and the eyes corresponds to a near point distance.

The near point distance is measured in the following procedure.

The user folds a sheet of newspaper or copy paper in an elongated form (at a width of about 3 to 5 cm) and puts it beside the personal computer (Fig. 50).

A near point distance measurement step 1: A near point distance measurement screen is transmitted so as to display a near point distance measurement target with three vertical lines on the screen (Fig. 51).

A near point distance measurement step 2: At this step, the user brings his/her face close to the screen as much as possible while covering the left eye with the left hand (Fig. 52(A)). At this time, he/she verifies that the target is blurred. Fig. 52(B) shows a state where the near point distance measurement target is viewed as blurred.

A near point distance measurement step 3: Next, the user positions his/her face away to the position where he/she can recognize the three lines displayed on the screen (Fig. 53(A)). He/she should be careful that they may be recognized at the position extremely close to the screen in some cases. A state where the near point distance measurement target is clearly seen is shown in Fig. 53(B).

A near point distance measurement step 4: Next, he/she stops the face at the position allowing the recognition. Then,

he/she rests his/her elbows on the desk and puts the folded paper on the temple. He/she picks the paper with the fingers in the eye corner area. A state of the user at this step is shown in Fig. 54.

A near point distance measurement step 5: Next, he/she puts the top of the folded paper perpendicularly to the screen without moving the face. A state of the user at this step is shown in Fig. 55.

A near point distance measurement step 6: Next, the paper is marked with the index finger of the left hand for the position of the right eye corner. After marking, the face may be moved. A state at this step is shown in Fig. 56.

A near point distance measurement step 7: At this step, the user presses a button "measure" on the upper left of the screen (Fig. 57).

A near point distance measurement step 8: The end of the paper is aligned with the position 0 of the "measure" appearing on the screen so as to measure a distance to the mark (Fig. 58). Three "measures" are displayed on the screen. If one measure is not sufficient, the paper is marked for the end of the measure and the remaining part is measured with the second one. If even two measures are not sufficient, the same operation is repeated for the third one.

A near point distance measurement step 9: Once "Next" button is clicked, a near point distance measurement target with

three horizontal lines is displayed on the screen (Fig. 59). A near point distance measurement step 10: The same check is carried out while the left eye is being covered with the left hand (Fig. 60).

A near point distance measurement step 11: When the length is measured, the check for the right eye is completed. Next, the left eye is checked in the same manner while the right eye is being covered with the right hand (not shown).

For the above-described near point distance measurement target, thin lines are used independently of vision of the subject.

Although the near point distance is measured for the target with three vertical lines and the target with three horizontal lines in the above description, the measurement is performed in the direction selected by the above-described astigmatism axis measurement and the direction perpendicularly crossing it. If the user is oblique astigmatic, the near point distance is measured in two directions at 45 degrees and 135 degrees.

The basic data measurement necessary for deciding a lens power is completed by the above operation. An eyeball optical model is constructed based on the basic data. In an eyeball optical model, an optical function of an eyeball within the range of accommodation of the user is detected so as to select a lens power. The selection of a lens power based on the

eyeball optical model will be described in detail in a lens power deciding system described below.

A second embodiment constituting the lens power deciding step will be described by using an optometry system as shown in Fig. 61. As illustrated, in this optometry system, a computer 6001 used by the subject and an optometry server 6010 providing an optometry method of the present invention are also connected to each other through the Internet 6002.

The optometry server 6010 is for providing an optometry service to the subject computer 1, and includes a WWW server 6020, a display screen database 6030, user interface means 6040, a subject database 6050, far point distance calculation means 6060, and lens power calculation means 6070.

The WWW server 6020 accepts an access from the subject computer 6001 so as to provide an optometry function in accordance with an optometry procedure of the present invention. An HTTP server is used so that the subject computer 6001 can be served by a general-purpose Web browser.

The display screen database 6030 stores screen data that the WWW server 6020 presents to the accessed subject computer in accordance with the optometry procedure of the present invention. In this case, the first guidance screen, a subject's attribute entry screen, an astigmatism axis determination screen, a far point vision test screen, a near point vision test screen, and the like are stored in an HTML

format.

The user interface means 6040 stores the attributes of the subject in the optometry information database 6050, activates the far point distance calculation means 6060 to calculate a far point distance or activates the lens power calculation means 6070 to calculate a lens power based on the information entered by the subject on the screen displayed by the WWW server 6020 on the subject computer 6001.

The user interface means 6040 is a process activated from the WWW server 6020 by a CGI, whereas the far point distance calculation means 6060 and the lens power calculation means 6070 are processes activated from the user interface means 6020. The optometry information database 6050 stores subject attribute data entered by the subject, selected direction data of the astigmatism axis determination chart(right and left eyes), visibility limit data based on the vision test chart (right and left eyes × two directions), near point distance data based on the near point distance measurement chart (right and left eyes × two directions), calculated far point distances (right and left eyes × two directions), calculated lens powers (right and left eyes) and the like.

Next, an example of a procedure of eye examination by such an optometry system will be described with reference to Fig. 62.

First, the procedure displays a subject attribute input

screen for acquiring the attributes of a subject (S10), and then acquires the attributes entered by the subject to store them as the subject data (S12). The attributes of the subject include the personal information such as the age, the gender, and the height, and wearing condition information regarding the situation where the spectacles or the contact lenses are mainly used. Fig. 63 is an example of a display screen for acquiring personal information, and Fig. 64 is an example of a display screen for acquiring wearing conditions. Here, it is assumed that the "reading" in the wearing conditions is for near distances, the " deskwork" and "personal computer" for intermediate distances, and the "driving cars" for far distances.

Then, the procedure displays an astigmatic axis measurement chart for determining the astigmatic axis (S14) to acquire the orientation that the subject has selected and store it as selected orientation data (S16). Fig. 65 is an explanatory view illustrating an example of a screen for use with the astigmatic axis measurement, Fig. 66 showing an example of the astigmatic axis measurement screen.

As illustrated, the astigmatic axis measurement chart is made up of four groups of a plurality of parallel lines, each group having lines extended in one orientation at an angle of 45 degrees, 90 degrees, 135 degrees, and 180 degrees, respectively. A subject with astigmatism experiences the

orientation which provides the sharper viewing and the orientations which provide the less-sharper blurry viewing, and is instructed to click on the zone in the orientation that provides a different viewing. The procedure instructs the subject to select the orientation that provides a different viewing as mentioned above. This is because astigmatism may possibly cause a 90 degree-inverted orientation to provide the sharper viewing depending on the distance to the object, and thus employing the orientation that provides the sharper viewing at the first gaze would possibly cause an error in measurement of the astigmatic axis. Therefore, the present invention is designed not to determine the main axis of the astigmatic axis at this stage but to determine the orientation that is longer in distance as the main axis by comparing the two far point distances calculated using the targets in two orientations at the later stage where a far point distance is calculated.

In principle, a subject without astigmatism is probably provided with the same viewing in all the orientations. Thus, the subject who clicks on "All are viewed in the same way" or "Indistinguishable" is considered to have no astigmatism and undergoes the following measurements only on the horizontal and vertical main axes.

The astigmatic axis measurement chart has the background in green and the lines in black, with the width of the lines

having two pixels and the width between the lines having three pixels. A background color of white causes a miosis and a greater depth of field in the eyes due to its excessive brightness, thus raising a problem of providing reduced difference in the way of viewing the four zones. This is why the eye-friendly green base color is used to reduce brightness. A color of black was employed as the color of the lines because a number of subjects who underwent an eye examination experiment determined consequently that black could be easily viewed. The width of the lines has at least two pixels because particularly in the case of a CRT display, one pixel may provide a different viewing between the horizontal/vertical and the diagonal direction due to the occurrence of focus blurring caused by the electron gun. The width between the lines was so set that the spacing between the lines could be recognized from a distance of 1m because an extremely short distance to the chart in the astigmatism measurement would invert the astigmatic axis by 90 degree, possibly resulting in an error in the measurement. A vision of 1.0 (an angle of view of 0.1 degrees) indicates the capability of distinguishing a slit of 0.29mm at a distance of 1m, which generally corresponds to one pixel on a 14-inch liquid crystal display or a 17-inch CRT. Therefore, two pixels correspond to a vision of about 0.5. However, since those who take the eye test need spectacles, the spacing was further expanded to have three

pixels.

On the other hand, the four orientations were provided for the astigmatic axis because of the following reasons. That is, this makes it possible to select sufficiently practical spectacles or contact lenses even using the four orientations, and the determination needs to be made as easily as possible without any error because the subject makes the determination by himself or herself.

Then, to measure the far point vision in the selected orientation that has been selected by the subject, the procedure displays the vision measurement chart for the selected orientation (S18) to acquire the viewing limit selected by the subject, which is then stored as first viewing limit data (S20). Fig. 67 is an explanatory view illustrating an example of a screen for a far point vision measurement, Fig. 68 showing an example of the far point vision measurement screen.

As illustrated, the vision measurement chart is a light and dark line image made up of three black lines and two white lines of a certain line width, a plurality of the charts being displayed in each of which the width of the lines are varied in I steps (from about 10 steps to 20 steps) corresponding to vision. On the vision measurement charts, the subject is instructed to click on the smallest mark that the subject can distinguish the three lines. Since the subject is allowed to

select the mark that provides the viewing of three lines as described above, the subject can make a determination more easily when compared with the Landoldt ring that is viewed to visually distinguish a single gap.

The subject is instructed to measure the far point vision at a reach from the computer screen. This is because the length of the arm is proportional in length to the height, and thus the distance between the subject and the chart can be predicted in accordance with the data on the height entered in advance.

As described above, the measurement can be conveniently carried out because the subject does not need to measure the distance to the computer screen or adjust the screen display size.

Likewise, to measure the far point vision in the orientation perpendicular to the selected orientation selected by the subject, the procedure displays the vision measurement chart in the orientation perpendicular to the selected orientation (S22), and the viewing limit selected by the subject is acquired and stored as second viewing limit data (S24).

Then, to measure the near point distance in the orientation selected by the subject, the procedure displays a near point distance measurement chart in the selected orientation (S26) to store the near point distance entered by

the subject as the first near point distance data (S28). Fig. 69 is an explanatory view illustrating an example of a screen for a near point distance measurement, Fig. 70 showing an example of the near point measurement screen.

As illustrated, the near point distance measurement chart has three black lines provided in a green background. The message on the screen instructs first the subject to move as close to the screen as possible and then move away therefrom to a position at which the subject can clearly see the three lines and measures the distance between the eyes and the screen, thereafter instructing the subject to input the distance in centimeters.

The near point distance measurement chart employs thinner lines compared with the aforementioned vision measurement chart regardless of vision of a subject, because the chart is viewed in close proximity to the computer screen. However, because of the difference in resolution due to the age, thin lines are used for the youth and slightly bolder lines are used for the middle aged and the elderly people.

To measure the near point distance in the orientation perpendicular to the selected orientation selected by the subject, the procedure displays a near point distance measurement chart in the selected orientation (S30) to store the near point distance entered by the subject as the second near point distance data (S32).

Then, the procedure determines the far point distance from the first viewing limit data, the first near point distance data, and the subject limit data to store the resulting distance as the first far point distance data (S34). Likewise, the procedure determines the far point distance from the second viewing limit data, the second near point distance data, and the subject limit data to store the resulting distance as the second far point distance data (S36).

The far point distance is operated using a neural network that a number of subjects have taught in advance. Fig. 71 is a view illustrating an exemplary configuration of a neural network for operating the far point distance. As illustrated, the input layer has I steps of far point vision (the viewing limit selected by the subject on the vision measurement chart), J steps of near point distance (the near point distance measured by the subject on the near point distance measurement chart), and K steps of subject attributes (the age, the gender, and the height), while the output layer has N steps of far point distance. The age and gender are employed as parameters because the accommodation ability of the eyes of the subject is varied due to them. The height, as described above, that is proportional to the length of the arm is used as a substitute parameter in order to adjust the distance between the subject and the screen to the length of the arm. As the method of learning, employed is the so-called back-propagation method,

but the method is not limited thereto.

Here, to make the conversion into the lens power easier, the near point distance of the input parameters and the far point distance resulted from the operation are each converted for handling to the value D (diopter) or the reciprocal of the distance measured in meters.

The neural network was designed to produce two independent learning models in the selected orientation of the astigmatic axis and the orientation perpendicular to the selected orientation to perform calculations for each of them separately.

Since different types of displays provide different ways of viewing the screens, the operation was performed using neural networks that had been separately taught depending on the display being either the liquid crystal display or the CRT.

The astigmatic axis determination (S14) through the far point distance calculation (S36) described above are performed for both eyes, right and left eyes, so as to calculate diopters (S: spherical diopter, C: cylinderical diopter and AX: axis of astigmatism) from the obtained selected direction data, the first far point distance data, and the second far point distance data (S38).

Assuming that the first far point distance obtained at S34 is D1, its direction is AX1, the second far point distance obtained at S36 is D2 and its direction is AX2,

when $|D1| < |D2|$, $S = D1$, $C = D2 - D1$, $AX = AX1$, and when $|D2| < |D1|$, $S = D2$, $C = D1 - D2$, $AX = AX2$.

Although the case where a diopter of the eye is merely calculated is described in the above embodiment, a diopter of a lens may be determined from the obtained diopter of the eye and the wearing conditions in the subject attribute data so as to accept an order of spectacles or contact lenses.

In this case, based on the wearing condition in the subject attribute data, a distance for which the spectacles or contact lenses are normally used is determined from any one of short-distance use (30 cm), intermediate-distance use (50 to 60 cm) and long-distance use (5 m) so as to determine a diopter of a recommended lens.

For example, for long-distance use, the far point distance D1 is corrected to be 5 m (-0.2 D). Therefore, a diopter of a recommended lens is D1 + 0.2 D.

Eyeball optical model generating means for generating an eyeball optical model based on the lens power calculated by the lens power calculation means and the attributes of the subject and naked eye focal performance confirmation means for confirming focal performance of a naked eye by using the generated eyeball optical model may be provided so as to check the validity of the calculated lens power. As a result, a lens power can be determined with higher accuracy.

Moreover, post-correction focal performance calculation

means for calculating focal performance after vision correction with a recommended lens by using the generated eyeball optical model may be provided so as to determine the recommended lens. As a result, a lens power more suitable to the subject may be presented.

Furthermore, sharpness score calculation means for calculating a sharpness score at a predetermined distance from a focal state with the recommended lens, image sample generating means for generating an image sample at the calculated sharpness score, and image sample display means for displaying the generated image sample on the computer screen are provided so that the subject confirms the image sample with the recommended lens on. As a result, since the subject can check how well he/she can see with the lenses on, a more suitable a lens power can be decided.

Although it is described that the far point distance calculation means uses a neural network that learns a large number of subjects to obtain the far point distance from the far point vision, the near point distance, and the attributes of the subject, the present invention is not limited thereto. The far point distance may be calculated by using a fuzzy inference so as to obtain a membership function or an inference rule from the data of a large number of subjects. Moreover, from the data of a large number of subjects, the relation between the far point vision and the far point

distance may be obtained as an approximate formula including the near point distance and the attributes of the subject as parameters so as to be used to calculate the far point distance. In this manner, the effects of the present invention can be obtained.

Although the near point distance serves as an input parameter in the calculation of the far point distance in the above embodiment, the present invention is not limited thereto. The near point distance may be omitted. In this case, since the near point distance is characteristic in being proportional to the age, the effects of the present invention can also be obtained.

Although it is described that the linear groups in four directions, each being formed by a plurality of parallel lines, are displayed on one screen in the astigmatism axis determination chart so that the subject selects the zone that appears dissimilar in the above-described embodiment, the present invention is not limited thereto. The linear groups in four directions may be individually displayed in a sequential manner so as to select the direction in which the zone appears dissimilar.

Although a plurality of charts, each being different in size, are arranged and displayed on one screen in the vision test chart so that the subject selects the limit of visibility in the above-described embodiment, the present invention is

not limited thereto. The charts in the respective sizes may be displayed in the larger order so that the limit of visibility is chosen by the subject.

Although the images of the selected direction in the astigmatism axis determination and the direction perpendicularly crossing it are displayed on the computer screen for the display of the vision test chart and the near point distance measurement chart in the above embodiment, the present invention is not limited thereto. The images of four directions may be stored in the display screen database 6030 in advance so that the image is selected therefrom for display. Alternatively, image data for a specific direction may be stored, whereas the images of the other directions may be generated by rotating the image with a graphic tool based on the direction data. Moreover, graphic data of the image to be displayed may be stored so that the images are drawn and generated by a drawing tool based on the direction data. As described above, by using a method of generating images by a graphic tool, a load on the image display is increased. However, since an image in an arbitral direction can be generated, a direction of the axis of astigmatism may be easily extended.

Similarly, for the display of a plurality of charts with varied line widths in the far point vision test, image data with a specific line width may be enlarged and reduced by a

graphic tool or may be drawn and generated by a graphic tool.

Although it is described that the display size of the astigmatism axis determination chart, the vision test chart, and the near point measurement chart on the screen is not particularly changed by the computer settings in the above embodiment, the present invention is not limited thereto. In order to obtain a lens power with higher accuracy, the screen settings of the computer may be acquired so as to change the display size of the screen based on them. The screen settings of the computer to be obtained are the type and the size of a display, the resolution settings of a computer, and the like. They may be automatically obtained from property information of the computer or may be input as the subject attribute data.

As described above, images may also be enlarged or reduced by a graphic tool or may be drawn by a drawing tool in this case.

Furthermore, although it is described that an experimentally determined optimal color is used as a display color of the astigmatism axis determination chart, the vision test chart, or the near point distance measurement chart in the above embodiment, the present invention is not limited thereto. A display color selecting function may be provided.

For example, color samples may be displayed in advance to the subject so that the subject can select the color that he/she likes, or a predefined color may be automatically

selected by screen setting of the computer for display.

Also for a display color of each of the charts, a plurality of display color patterns may be stored in advance so that a selection can be made therefrom. It is apparent that an image in a specific display color pattern may be color-converted by a graphic tool or may be drawn by a drawing tool.

Similarly, although it is described that an experimentally defined optimal brightness is used for a brightness of a background or a segment of the astigmatism axis determination chart, the vision test chart, and the near point measurement chart in the above embodiment, the present invention is not limited thereto. A display brightness selecting function may be provided.

Also for a display brightness of each of the charts, a plurality of display brightness patterns may be stored in advance so that a selection can be made therefrom. It is apparent that an image in a specific display brightness pattern may be brightness-converted by a graphic tool or may be drawn by a drawing tool.

Although it is described that the attribute data of the subject is acquired each time the subject receives an optometry service in the above embodiment, the present invention is not limited thereto. It is apparent that the attribute data is prestored as a customer database so that necessary data is extracted from the database. As described

above, the customer database is provided so as to store a history of the optometry services provided so far and data of sold spectacles and contact lenses in addition to the subject attribute data described above. As a result, more accurate optometry in accordance with the characteristics of the subject can be carried out so as to present more proper corrective lenses.

It is described that the eye examination is carried out mainly for short-sighted persons who are also astigmatic in the above embodiment. However, since the near point distance is obtained in addition to the far point distance in this embodiment, the eye examination may also be carried out for subjects who are long-sighted or presbyope based on it.

More specifically, if the far point distance is extremely long and the near point distance is long too, there is a possibility that he/she may be long-sighted or presbyope. If the accommodation ability of eyes of the subject is obtained, the determination of longsightedness or presbyopia can be made based on it.

Therefore, for example, the age or gender of the subject is used as a substitute parameter for the accommodation ability of eyes. A neural network, which uses the far point distance, the near point distance, and the attributes of the subject (age and gender) as inputs and outputs the diopter of astigmatism and the diopter of long-sightedness, is made to

learn a large number of subjects who are long-sighted or presbyope. By using it, the diopter of long-sightedness or presbyopia may also be calculated.

Moreover, the accommodation ability of eyes of the subject may be actively measured by using a computer screen so as to determine the diopter of long-sightedness or presbyopia based on it. For this determination, for example, a method of measuring the tracking ability of an image traveling on the computer screen, measuring the visibility when the subject moves changing a distance with the computer screen in a rapid cycle or the like is conceivable. In this manner, not only short-sighted persons who are also astigmatic but also subjects who are long-sighted or presbyope may be dealt with. Therefore, an optometry system for everybody can be constructed.

According to the present invention, the attributes of the subject are obtained. In addition, the astigmatic axis determination chart is displayed on the computer screen so as to obtain the direction selected by the subject. The vision test chart is displayed for the obtained direction and the direction perpendicularly crossing it so as to obtain the limit of visibility selected by the subject. The far point distances are calculated from the obtained limit of visibility and the obtained attributes of the subject so as to calculate the lens power from the obtained direction and two calculated

far point distances. Therefore, the present invention is effective in that the subjects who are astigmatic can be dealt with and the eye examination can be carried out in a simple manner by using the computer screen without requiring any special equipment.

Next, a third embodiment of the lens power deciding step described above will be described by using a lens power deciding system shown in Fig. 72. The lens power deciding system is for constructing an optical model of an eyeball of the user to decide a power of a corrective lens, and includes a central processing unit 8012. The central processing unit 8012 controls the operations of: a data input section 8014; an input data check section 8016; a far point distance calculating section 8018; a start eyeball optical model deciding section 8020; an eyeball optical model focal performance calculating section 8022; a model validity examining section 8024; an eyeball optical dimensions-accommodation range determining section 8026; an eyeball optical model deciding section 8028; a viewed image generating section 8030; a sharpness score generating section 8032; and a display section 8036. Hereinafter, the schema of each of the sections controlled by a central control unit 12 will be described.

The data input section 8014 is for inputting the age of a person who wants to wear corrective lenses such as spectacles

or contact lenses, the conditions of use of the corrective lenses, the axis of astigmatism, the far point vision, and the near point distance. The data input section 8014 is composed of equipment such as a keyboard, a mouse, or a touch panel to which a person directly inputs data or equipment configured to be able to receive data through a network by using a modem, a LAN card, or the like, and a program for controlling the equipment.

The far point vision in this embodiment does not mean a generally used power unit such as 1.5 but another numerical unit. Hereinafter, the far point vision will be described in detail. On a display such as a computer, targets as shown in Fig. 73 are displayed. The subject perfectly stretches out his/her arms while touching a display with fingers. He/she perfectly stretches out the arms with the ramrod-straight posture. In this state, the targets for measuring a vision are sequentially displayed in the larger order on the display as shown in Figs. 73(a) to 73(c). The subject selects the smallest one of the displayed targets, of which black three lines can be clearly seen. The number assigned to the target selected by the subject is determined as the far point vision. The far point distance can be calculated from the far point vision.

The input data check section 8016 checks the consistency of the input value from a value of the data input to the data

input section 8014. The input data check section 8016 stores therein a large amount of stored standard sample data 8016a in which data of the axis of astigmatism, the far point distance, and the near point distance are associated with each other on the basis of the age. The input data check section 8016 determines whether a value of the data input to the data input section 8014 is valid as a result of comparison with the standard sample data 16a.

The far point distance calculating section 8018 calculates the far point distance from the far point vision corresponding to the data input to the data input section 8014. The far point distance calculating section 8018 stores data related to age, gender, height, far point vision, and the near point distance. Based on the input data of age, gender, height, far point vision, and near point distance, the far point distance calculating section 18 calculates the best far point distance that is the most suitable to the data.

The start eyeball optical model deciding section 8020 decides a start eyeball optical model based on the age of the subject and the approximated lens power.

Now, the eyeball optical model will be explained below. In the eyeball optical model, light-beam refractive elements of a human eye, as shown in Fig. 74, are configured as an mathematical/physical numerical model as a lens. As shown in Fig. 74, the eyeball optical model comprises light-ray

refractive elements of the eyeball such as the cornea, the anterior chamber, the lens of the eye, and the vitreous body, and the retina. An eyeball optical model is constructed with respect to these light-beam refractive elements in accordance with the following optical dimensions.

Cornea: the radius of curvature R3 of the front surface, the thickness, the refractive index, and the radius of curvature R4 of the rear surface

Anterior chamber: the thickness and the refractive index

Lens of the eye: the radius of curvature of anterior cortex (the radii of curvature R5, R6, R7, R8, R9, and R12) and the thickness of the anterior cortex; the radius of curvature of nucleoplasm (the radii of curvature R13, R14, R15, R16, R17, R18, R19, R20, R21, R22, R23, R24) and the thickness of the nucleoplasm; and the radius of curvature of posterior cortex (the radii of curvature R25, R26, R27, R28, R29, R30, R31, R32, and R33) and the thickness of the posterior cortex and their respective refractive indices

Vitreous body: the refractive index and the thickness

Retina: Radius of curvature R34

The aforementioned optical dimensions are different from each other depending on the age and the accommodation ability of the eye of each individual. However, in this embodiment, an eyeball optical model is pre-constructed as a standard pattern with reference to values from living body measurement data on

Japanese people. For example, regarding the anterior chamber,

Depth of anterior chamber: the depth of anterior chamber is 3.66mm for the ages of 8-15, 3.71mm for the ages of 16-30, 3.51mm for the ages of 31-51, 3.18mm for the ages of 51-77.

Length of the eye axis: the length of the eye axis shows a tendency contrary to the aging tendency of the depth of anterior chamber.

Lens of the eye: there is uneven distribution of refractive indices. The refractive index of the surface is irrelevant to age, but the refractive index of the nucleus of the lens of the eye increases a little by aging. The weight of thickness increased by aging is 174mg for the ages of 20-39, 204mg for the ages of 40-59, and 266mg for the ages of 80-99.

Although the eyeball optical model is constructed based on the aforementioned values in this embodiment, the eyeball optical model may also be constructed based on the values listed in the literature data. The following is an example of literature data applicable to the construction of an eyeball optical model.

(i) Concerning the depth of the anterior chamber

According to "Study on the depth of anterior chamber" by Katsuo Aizawa, Japanese Ophthalmological Society Journal Vol. 62, No. 11 (1958), the relationship between the depth of the anterior chamber and the age varies as follows:

3.66mm for ages from 8 to 15,

3.71mm for ages from 16 to 30,

3.51mm for ages from 31 to 51, and

3.18mm for ages from 51 to 77.

That is, the study tells that the depth of the anterior chamber tends to gradually increase as the body grows from the youth and reach the maximum level when the body has grown up, thereafter gradually decrease as the body deteriorates.

(ii) Concerning the length of the eye axis

According to "Study No. 1 on the essence of shortsightedness" by Tsutomu Sato, et al, Japanese Ophthalmological Society Journal Vol. 63, No. 7 (1959), for the low degree of shortsightedness, the length of the eye axis gradually increases as the degree of myopia becomes higher, showing a strong correlation therebetween.

(iii) Concerning the weight of the lens of the eye

According to "The eye" by Davson Hugh (1909-) and Graham L.T. Jr., New York; London Academic Press, the weight of the lens of the eye only increases with advancing age as follows:

174mg for ages from 20 to 39,

204mg for ages from 40 to 59, and

266mg for ages from 80 to 99.

(iv) Concerning the thickness and diameter of the lens of the eye

According to Complete Collection of New Clinical Ophthalmology 3A, by Hiroshi Ichikawa, et al, 1993, KANEHARA &

CO., LTD, the thickness and diameter of the lens of the eye increases with advancing age.

The eyeball optical model that has been pre-constructed by applying the aforementioned values is used as the start eyeball optical model determined by the start eyeball optical model deciding section 8020. The start eyeball optical model is not constructed for the combinations of all ages and approximate lens powers, but with attention being given to the fact that the start eyeball optical model has generally common eye characteristics for the same age and approximate lens power, such an eyeball optical model is pre-constructed, which has a median value in each age class represented on the vertical axis and a median value in each approximate lens power class represented on the horizontal axis. The vertical axis representing M classes and the horizontal axis representing N classes allow for constructing M by N start eyeball optical models. That is, employed is a table in which the vertical axis represents the age class (e.g., at five year intervals up to twenty years of age, and at 10 year intervals for 20 years of age or more) and the horizontal axis represents the approximate lens power (e.g., at intervals of 1.0D). With this table, such a start eyeball optical model is pre-constructed at a combination of median values in each class (e.g., the 35 years of age and the lens power of the amount of correction required being -2.5D).

M × N eyeball optical models are constructed as start eyeball optical models. Among them, the start eyeball optical model deciding section 8020 uses the eyeball optical model having the closest value as a start eyeball optical model although in this embodiment, it is not limited thereto. A start eyeball optical model may be constructed from the values of the constructed eyeball optical models based on the most suitable value of a light-beam refractive element from the measured age and approximated lens power.

The start eyeball optical model decided in the start eyeball optical model deciding section 8020 is used as an initial value in the eyeball optical model deciding section 8028 described below to perform an optical system design automation process for constructing an eyeball optical model proper to the person. In this start eyeball optical model, the design automation process is terminated within a short time and therefore the processing speed can be reduced as compared with an optical system design automation process using an independent start eyeball optical model which is not based on the age or the approximated lens power. Moreover, the reliability of solutions (optical dimensions enabling the best focal state) is high.

The eyeball optical model focal performance calculating section 8022 calculates focal performance of the eyeball optical model in a naked eye state of the subject or with

corrective lenses. As a state of the eyeball for calculating a focal state, there is a state at the near point or the position within the range of accommodation ability in the vicinity of the near point, a state at the far point or the position within the range of accommodation ability in the vicinity of the far point, or a state at the position away from the near point and the far point.

The model validity examining section 8024 examines the validity of the eyeball optical model at the limit of accommodation on the near point side and/or on the far point side based on the focal performance calculated by the eyeball optical model focal performance calculating section 8022.

The eyeball optical dimensions-accommodation range determining section 8026 determines the range of accommodation of the eyeball at an accommodation midpoint from the input near point distance and the calculated far point distance. Furthermore, the eyeball optical dimensions-accommodation range determining section 8026 is configured to generate an image of the eyeball optical model in which the range of accommodation of the eyeball at the accommodation midpoint is determined.

The eyeball optical model deciding section 8028 adjusts the values of the optical dimensions of the start eyeball optical model so that the focal state in the eyeball of the subject at the midpoint of accommodation calculated from the

near point distance and the far point distance of the subject becomes optimal, thereby deciding the eyeball optical model fitted to a state of the eye of each person.

The viewed image generating section 8030 generates visual images viewed by the subject before and/or after the correction by means of a corrective lens based on the result calculated in the eyeball optical model focal performance calculating section.

The sharpness score generating section 8032 derives the sharpness score that indicates mathematically the degree of sharpness of viewing by the subject before and/or after the correction by means of a corrective lens.

The sharpness score indicates how sharply an image is viewed in an arbitrary numerical value and is calculated, for example, so that the higher numerical value indicates that the image is more sharply seen.

The lens power selecting section 8034 examines optical performance when the subject wears spectacles or contact lenses to select a lens power.

The display section 8036 is a display device for confirming an operation condition of a corrective lens deciding server 8010 or for confirming a value of the data input by the subject or the calculated data. As the display section 8036, a display connected to the computer or a display of the computer connected to the corrective lens deciding

server 8010 via the data input section 8014 is used.

Next, an operation of the present invention will be described with reference to Fig. 75.

(1) The gender, the age, the axis of astigmatism, the near point distance, the far point vision, and the conditions of use of corrective lenses (for reading, deskwork, driving, and the like) of the subject are input by using the data input section 8014.

(2) The input data is examined by the input data check section 8016.

(3) The far point distance is calculated from the far point vision by the far point distance calculating section 8018.

(4) By using a relational table of the range of accommodation in terms of age, supposing an average range of accommodation at an assumed age, eyeball refractivies at the upper limit and the lower limit of the range of accommodation are derived. Based on them, the near point distance and the far point distance are corrected.

(5) A midpoint in the range of accommodation of the eyes of the subject is obtained from the near point distance and the far point distance. Furthermore, the approximated lens power is calculated.

(6) A start eyeball optical model is decided by the start eyeball optical model deciding section 8020 from the age and

the value of the approximated lens power.

(7) The focal performance is calculated by the eyeball optical model focal performance calculating section 8022 using the decided start eyeball optical model. The ultimate eyeball optical model in an intermediate state of the accommodating function of the eyes is decided by the eyeball optical model deciding section 8028. More specifically, a light beam is incident on the eyeball optical model in the accommodation midpoint state by the eyeball optical model focal performance calculating section 8022 so as to calculate the focal performance of the light beam on a retina. The optical system design automation process is performed to achieve the best focal state. The optical dimensions are changed by the eyeball optical model deciding section 8028 to determine optimal solutions (optical dimensions). In the construction of the eyeball optical model at the accommodation midpoint, the automatic optical design calculation begins with the aforementioned start eyeball optical model to automatically determine the optical dimensions of a human eyeball so as to provide the optimal focal performance.

As used herein, the automatic optical design calculation refers to the automatic process for determining optical dimensions by light beam tracking using an automatic lens design program. As a typical example of these techniques, the dumped least squares method is available.

The calculation minimizes the sum of squares of the amount of deviation in position from the point of arrival of light on the retina while the values of the optical dimensions of the eyeball optical model are being gradually varied (a radius of curvature and an intervals of surfaces are varied while a refractive index is unchanged; in the case of non-spherical surface, a radius of curvature of reference spherical surface and aspherical surface coefficient are varied) to satisfy a final performance condition (in this embodiment, a focal state in which the cases where a plurality of beams of light are impinged from an infinitesimal point object located in the accommodation midpoint condition upon the pupil diameter (e.g., φ =3mm) of the eyeball optical model at various heights of incidence are calculated to track the refraction change of beams of light, thereby allowed to focus onto a point on the retina). This is the same as in an "eyeball optical model construction process of a person at the midpoint of accommodation" described below.

(8) The model validity examining section 8024 is used to check the validity of the eyeball optical model at the accommodation limit (on the near point side). In this validity check, the eyeball refractive power is brought up (UP) by the amount of accommodation ability of a human eyeball, and then the automatic optical design calculation is performed to confirm a good focal performance.

As used herein, the "bringing up (UP) the eyeball refractive power by the amount of accommodation ability" means as follows. Assuming that the far point distance is 1m (-1.0D) and the near point distance is 25cm (-4.0D), the accommodation midpoint position is 40cm (-2.5D) and an UP in the eyeball refractive power corresponding to the amount of correction of -1.5D is required on the near point side with respect to the accommodation midpoint position. As described above, an increase in eyeball refractive power corresponding to this -1.5D is provided as follows. While the boundary conditions for the automatic optical design are being controlled, a plurality of beams of light are impinged from an infinitesimal point object located at a near point distance of 25cm upon the pupil diameter (e.g., φ =3mm) of the eyeball optical model at various heights of incidence to track the beams of light. Thus, the automatic optical design is performed while the optical dimensions are being varied so as to focus the beams of light on a point on the retina.

Suppose that this has conceivably resulted in the convergence of the light on one point. In this case, it is determined that the optical model has been successfully simulated at the accommodation limit, and the eyeball optical model of the subject is valid at the accommodation midpoint.

(9) The model validity examining section 8024 checks the validity of the eyeball optical model at the accommodation

limit (on the far point side). In the validity check, the eyeball refractive power is brought down (DOWN) by the amount of accommodation ability of a human eyeball, and then the automatic optical design calculation is performed to confirm a good focal performance.

As used herein, the "bringing down (DOWN) the eyeball refractive power by the amount of accommodation ability" means as follows.

Assuming that the far point distance is 1m (-1.0D) and the near point distance is 25cm (-4.0D), the accommodation midpoint position is 40cm (-2.5D) and a DOWN in the eyeball refractive power corresponding to the amount of correction of +1.5D is required on the far point side with respect to the accommodation midpoint position. As described above, a decrease in eyeball refractive power corresponding to this +1.5D is provided as follows. The boundary conditions for the automatic optical design are being controlled, a plurality of beams of light are impinged from an infinitesimal point object located at a far point distance of 1m upon the pupil diameter (e.g., φ =3mm) of the eyeball optical model at various heights of incidence to track the beams of light. Thus, the automatic optical design is performed while the optical dimensions are being varied so as to focus the beams of light on a point on the retina.

Suppose that this has conceivably resulted in the

convergence of the light on one point. In this case, it is determined that the optical model has been successfully simulated at the accommodation limit, and the eyeball optical model of the subject is valid at the accommodation midpoint.

(10) The model validity examining section 8024 checks the validity of the eyeball optical model outside the accommodation limits on the near and far point sides, i.e., outside the range of accommodation of the eyeball.

(11) The eyeball optical dimensions-accommodation range determining section 8026 finally determines the range of accommodation of the eyeball optical dimensions for the eyeball optical model at the accommodation midpoint position.

(12) An image of the decided eyeball optical model, for example, a cross-sectional view of an eyeball as shown in Fig. 74 is generated by the eyeball optical dimensions-accommodation range determining section 8026. The description for the eyeball optical model may be displayed therewith.

(13) The focal performance with the accommodation at three distances in a naked eye state of the subject is calculated by the eyeball optical model focal performance calculating section 8022.

The eyeball optical model at the accommodation midpoint position and the range of accommodation of the optical dimensions are determined as follows.

The model validity examining section 8024 performs the

processing for checking the validity of the eyeball optical model at the accommodation limit (on the near point side) and the model validity examining section 8024 performs the processing for checking the validity of the eyeball optical model at the accommodation limit (on the far point side). These checks determine, as a result of the processing for constructing an eyeball optical model of the person at the accommodation midpoint, that the eyeball optical model is valid at the accommodation midpoint position. The eyeball optical model is then used in the focal performance calculation processing, discussed later, which is accompanied by accommodation at the three distances with the eye uncorrected, and the focal performance calculation processing which is accompanied by accommodation at the three distances with the eye corrected. "The three distances" is chosen such that the viewed image is possibly changed remarkably, e.g. 0.3m (for reading), 0.5m - 0.6m (for deskwork), and 5m (for car driving). It can be said that the range of changes in optical dimensions at the accommodation limits (in particular, the range of changes in thickness of the lens of the eye within which the lens of the eye is made thinner or thicker, in the radius of curvature of the front surface, and in the radius of curvature of the rear surface) has also been determined by the model validity examining section 8024 performing the processing for checking the validity of the

eyeball optical model at the accommodation limit (on the near point side) and the model validity examining section 8024 performing the processing for checking the validity of the eyeball optical model at the accommodation limit (on the far point side). The determination of them makes it possible to simulate the accommodation of the eye according to the distance to an object. The amount of an increase (UP) or a decrease (DOWN) in eyeball refractive power from the accommodation midpoint position is determined according to the distance to an object to perform the automatic optical design while the boundary conditions are being controlled, like the processing of the model validity examining section 8024 for checking the validity of eyeball optical model at the accommodation limit (on the far distance side).

The optical dimensions determined as described above represent the condition of the eye in which the eyeball virtually performs focus accommodation.

The calculation is repeated until no more improvement can be made in focal performance, and the resulting optical dimensions are determined as the best focal performance at the distance to the object.

To evaluate the focal performance, several hundreds of beams of light equally dispersed are impinged from an infinitesimal point object located at a certain distance upon the pupil diameter (e.g., φ =3mm) of the eyeball optical model

to track the beams of light, thereby calculating where the beams of light are focused on the retina. To evaluate the degree of blurring, the two-dimensional Fourier transform is performed on the intensity distribution of a point image on the retina, thereby calculating the spatial frequency characteristics (OTF) to evaluate the image.

(14) The focal performance with the accommodation at three distances described above for the optical model after vision correction with corrective lenses is calculated and examined by the eyeball optical model focal performance calculating section 8022.

That is, an actual spectacle lens (with known radii of curvature of the front and rear surfaces of the lens and a known refractive index of the glass material) is placed in front of the eyeball optical model to perform a calculation like the focal performance calculation processing with the eye uncorrected.

From the approximate lens power and the wearing conditions, an appropriate virtual lens is determined to perform an optical simulation on the focal performance with the spectacle/contact lens being worn.

On the other hand, when the balance between the sharpness scores at the three distances is badly kept, the lens power is slightly varied to perform the optical simulation again.

(15) The sharpness score generating section 8032 is used

to vary the optical dimensions of the eye within the range of accommodation ability to create the condition in which the focal performance is optimally provided, calculating the sharpness score at that time. The relationship between the sharpness score and the viewed image is illustrated in Fig. 76. The sharpness score is calculated based on the result of focal condition calculated by the eyeball optical model focal performance calculating section 8022.

Several hundreds of beams of light equally dispersed are impinged from an infinitesimal point object located at a certain distance upon the pupil diameter (e.g., φ =3mm) of the eyeball optical model to track the beams of light, thereby calculating where the beams of light are focused on the retina. A value obtained by the two-dimensional Fourier transform being performed on the intensity distribution of the point image is called the spatial frequency characteristics (OTF). Checking how the intensity is distributed on the retina makes it possible to evaluate the degree of blurring. The spatial frequency is a value which represents the fineness of a stripe pattern and is defined as the number of stripes per unit length.

For a visual system, it is represented by the number of stripes per visual angle of 1 degree. For example, assuming that the spacing of the stripes is w (degrees), it is given that u=1/w (cycles/deg).

The value of w used for the evaluation of blurring is found from the resolution of the retina, allowing the sharpness score to be calculated based on the value of u provided at that time.

(16) The viewed image generating section 8030 is then used to generate and display visual images at the three distances before and after the correction with the recommended lens (Fig. 77). By this processing, the user can confirm on the screen the ways of viewing with the uncorrected eye and with the recommended lens being worn.

The viewed image generating section 8030 is used to prepare images at the three distances which are photographed at high resolution. Generation of the view images is performed such that the N by N size smoothing filter processing is performed on these images pixel by pixel to blur the images to blur the images. The degree of blurring can be adjusted by the value of N (at a minimum of 3), filter weighting, and the number of times of the processing. The spatial frequency analysis is performed on the images that have been filtered in order to determine the degree of blurring, which is in turn associated with the sharpness score that has been determined through the calculation of the sharpness score. Several images are prepared which correspond to some sharpness scores. Furthermore, the score values are calculated which correspond to the images obtained by the special smoothing filter

processing being performed once on the prepared images.

The score value determined by the calculation of the sharpness score is used to directly call the corresponding image for display or to filter the image to display the resulting image corresponding to its sharpness score.

(17) Furthermore, images showing the respective views at three distances are presented for comparison by the viewed image generating section 8030 while replacing lens. More specifically, a lens power is changed to perform an optical simulation with spectacles or contact lenses on. Then, the optical dimensions are changed within the range of accommodation of the eyeball to create a state where the focal performance is optimal. A sharpness score at that time is calculated.

If a sharpness score at a specific lens power has already been calculated by the lens power selecting section 8034, it may be configured to use the data.

(18) The subject visually determines a corrective lens at a corrective power that he/she desires from the displayed viewed image and sharpness score so that the number, code or the like indicating the corrective lens to be used is selected by the data input section 8014.

As described above, this lens power deciding system includes: the input means for inputting information related to a state of the eyes of the user; the eyeball optical model

deciding means for deciding an eyeball optical model in accordance with the information related to the input state of the eyes; the eyeball accommodation range determination means for examining optical performance of the eyeball within the range of accommodation of the user in the decided eyeball optical model to determine the range of accommodation of the eyeball; and the lens power selecting means for examining the optical performance when the user wears spectacles or contact lenses to select a lens power. Therefore, a lens power of spectacles or contact lenses fitted to eyes of each person can be decided.

In the above description, the spectacle and contact lens selecting system, the spectacle virtual try-on system, and the remote subjective vision test system are described as independent spectacle order/sales centers, respectively. In practice, however, they are integrated on a single computer or server to share the database, or they are integrated by performing a distributed processing with a plurality of computers or servers so that the user information, the frame selection information, the vision test information, and the like are intercommunicated through a LAN and the like. As a result, the user accesses from a single user client to a single site to receive a series of order/sales services of spectacles or contact lenses.

The lens power may be decided by using a lens power

obtained by the lens power deciding system or by using a lens power obtained by the optometry system.

Moreover, owing to the spectacle and contact lens selecting system obtained by the integration of the lens power deciding function by the remote subjective vision test system, the lens power deciding system or the optometry system as described above and the frame selecting function by the above-described spectacle virtual try-on system, lenses fitted to eyes of each person can be remotely selected. In addition, a frame or the like can be selected after visual confirmation of a wearing state of each person. Therefore, the user is assured to receive the order/sales services of spectacles or contact lenses through a network such as the Internet.

Although the user client, the spectacle order/sales center, and the external payment transaction agency are connected by the Internet in the above embodiment, the present invention is not limited thereto. It is apparent that they are partially or entirely connected through a LAN, a WAN or the like within a specific organization. Moreover, the present invention is not necessarily limited to the case where the optometry service is provided for the subject through the network. The spectacle and contact lens selecting system according to the present invention may be installed in a store or the like to provide the order/sales service of spectacles in a stand-alone fashion.

Although the spectacle and contact lens selecting system is described in the above embodiment, according to the spectacle and contact lens selecting method including the respective means in the spectacle and contact lens selecting system of the present invention as steps, the effects of the present invention can be obtained independently of a hardware structure.

Since the method of the present invention can be realized by a general-purpose personal computer, a computer program describing the method of the present invention in an executable manner in the personal computer may be provided for the user so as to provide a selection service of spectacles or contact lenses. It is apparent that the computer program may be provided by a recording medium such as a CD-ROM or may be provided for the user by downloading it through the Internet or the like.

As described above, according to the present invention, easy selection of spectacles and contact lenses fitted to eyes of each person can be ensured.